

SELECT COMMITTEE ON
SCIENCE AND TECHNOLOGY

SYSTEMATIC BIOLOGY
RESEARCH

VOLUME II—ORAL EVIDENCE
AND
WRITTEN EVIDENCE RECEIVED AFTER 21st MAY 1991

Printed pursuant to the Order of the House of Lords of 17th December 1991

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Tuesday 26 March 1991

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**
(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 26 March 1991

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THE SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY
(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

TUESDAY 26 MARCH 1991

OFFICE OF ARTS AND LIBRARIES

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Butterworth, L
Dainton, L (Chairman)
Flowers, L
Nicol, B

Porter of Luddenham, L
Selborne, E
Taylor of Blackburn, L
Whaddon, L

Written evidence from OAL on Corporate Planning arrangements for the National Museums and Galleries and on the Natural History Museum in particular

Background

The responsibility for the management of each national museum or gallery is vested in its Trustee body, which is appointed by the Prime Minister. The Office of Arts and Libraries (OAL) sets a broad policy framework and provides grant for running costs, building and maintenance, and acquisitions. A Financial Memorandum sets out the limits of delegated authorities for the museum, the requirements for the establishment of proper financial controls, management and information systems within the museum; and the reporting arrangements for OAL. A copy of the Natural History Museum's (NHM) Financial Memorandum is at A – this document is currently under review.

The main instrument of OAL's oversight is the annual corporate plan. This sets out the museum's aims and objectives; financial projections; including its plans, priorities and bids for funding over the next five years.

The OAL considers all the national museums' and galleries' plans and discusses them with the director and senior museum staff prior to advising the Minister on his priorities for the forthcoming spending round. The formal response to the plan takes the form of a firm allocation of funds for the three years ahead with any explanation of factors which were taken into account in setting these allocations; together with general policy guidance, and inputs to the next planning round. The detailed elements of the plan are not specifically approved. The NHM 1990 plan is attached at B and the Minister's allocation letter responding to the plan is at C. A note showing NHM funding from 1985/86 is attached at D.

Three-Year Settlements

Funding for the NHM, in common with all the national museums and galleries sponsored by the OAL, is determined on the basis of a rolling three-year programme.

This arrangement stems from a 1987 announcement by the then Minister for the Arts, Richard Luce. The aim is to provide a firm basis for museums and galleries to plan their future activities including capital works. In addition the introduction of the scheme was intended to allow institutions to plan the fund-raising and income generation which they would undertake on their account; and to match their plans and priorities to a realistic view of the total resources institutions can secure for themselves over a three-year period.

The keynote of the scheme is that once figures for the three years have been settled they are not intended to be reviewed unless substantial and unforeseen changes occur. Nevertheless it should be noted that the three-year allocations were reviewed in November 1989 and November 1990 mainly as a response to the higher than predicted rates of inflation which fed through to running cost pay increases.

The Natural History Museum

The Natural History Museum announced in April 1990 a major reorganisation of the Museum's administrative and research priorities. These changes and their implications for the future of the Museum were set out fully in the 1990 corporate plan which was published in parallel with its submission to the OAL. The key objectives of the reorganisation were to strengthen curation; focus research efforts more sharply into areas of particular importance; to improve management of the collections; to develop exhibition facilities and other services for all who use the Museum. These specific plans were formulated following internal consultation with scientific staff over technical matters and with the wider scientific community via a series of peer group reviews. After publication of the corporate plan, and at the same time as they launched an explanatory leaflet called *Strategy for Science*, the Museum arranged an open meeting with leading members of the scientific community to discuss its overall strategy. A copy of the leaflet is attached at E.

In addition I attach a copy of the Natural History Museum 1987-89 Triennial Report at F.

Office of Arts and Libraries

21 March 1991

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[Continued

Annex A**FINANCIAL MEMORANDUM FOR THE BRITISH MUSEUM (NATURAL HISTORY)**

1. This Memorandum sets out the arrangements and conditions for the payment by the Office of Arts and Libraries (OAL) of the grant-in-aid to the Board of Trustees of the British Museum (Natural History) (the Trustees) out of moneys provided by Parliament. The grant-in-aid will be paid to the Trustees to enable them to carry out the objects set out in the British Museum Act, 1963.

2. The conditions set out below do not alter the duties and powers of the Trustees under the statute, either for the management of the British Museum (Natural History) or for the acquisition and care of its collection. They are in addition to, and not in substitution for, any guidelines or directions issued by the Minister for the Arts (the Minister) or by the OAL on his behalf in respect of any of the individual functions, powers and duties of the Trustees.

THE ACCOUNTING OFFICER OF THE OFFICE OF ARTS AND LIBRARIES

3. The Accounting Officer of the OAL is responsible for the issue of grant-in-aid, and for ensuring it is within the ambit and amount of the Vote, and that Parliamentary authority has been sought and given. The OAL Accounting Officer is also responsible for satisfying himself that the financial and other management controls applied by the OAL are appropriate and sufficient to safeguard public funds; that those being applied by the British Museum (Natural History) conform to the requirements both of propriety and of good financial management, and that the institution observes the conditions of this Memorandum in the uses which are made of grant-in-aid moneys.

THE ACCOUNTING OFFICER OF THE BRITISH MUSEUM (NATURAL HISTORY)

4. The Director of the British Museum (Natural History) will be appointed by the OAL as Accounting Officer (the Museum's Accounting Officer) for the Trustees' expenditure from the grant-in-aid. He shall act in accordance with the terms of his letter of appointment and of this Memorandum. In particular the Museum's Accounting Officer:

a. shall

- i. advise the Trustees on the discharge of their responsibilities under this Memorandum;
- ii. ensure the good and efficient management of the Museum's assets and operations;
- iii. plan and control expenditure;
- iv. seek to ensure that financial considerations are taken fully into account at all stages by the Trustees in framing and reaching decisions, and in their execution;
- v. inform the Trustees in writing, if their instructions conflict with his duties as Museum's Accounting Officer. Should the Trustees decide, nevertheless, to proceed, he should comply with their written instruction to do so and inform the OAL of the situation;
- vi. personally sign the accounts, and cause records to be maintained relating to accounts;

b. has the personal authority to write-off losses, and make special payments, as indicated in Annex A below;

c. shall be personally associated with the OAL Accounting Officer on matters relating to the grant-in-aid which arise before the Public Accounts Committee.

5. The Trustees may delegate to the Museum's Accounting Officer such of their responsibilities under this Memorandum as they deem appropriate. The Museum's Accounting Officer may be assisted in the exercise of his functions by employees of the Trustees, but shall not assign absolutely to any other person the responsibilities in sub-paragraphs 4a-c above. He shall have regard to such general guidance on the responsibilities of Accounting Officers as may be issued from time to time by the Treasury.

6. References to the Museum throughout this Memorandum assume the allocation of responsibilities between the Trustees, the Director as Accounting Officer, and other staff of the Museum, set out in paragraphs 1-5 above.

Planning

7. The Museum shall send to the OAL by an agreed date each year, a corporate plan which sets out for the next five years:

- a. the Museum's objectives and its priorities within those objectives;
- b. expected resources, including options for developing non-grant-in-aid sources of funds;
- c. the application of resources to planned activities;
- d. the targets to be achieved; and

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[Continued

e. the performance measures by which the achievement of the objectives will be assessed.

8. The Museum shall also provide such other information about its existing and proposed activities as the OAL may from time to time request.

9. Major building and maintenance projects. In addition to the information provided by the Museum in the corporate plan or supplementary documents, the Museum shall conduct an investment appraisal and shall send the OAL separate proposals for each new building or maintenance project involving expenditure (including fees, fitting out and VAT) of £250,000 or more, whether the proposed finance is from public or private funds or a combination of the two. The proposal shall describe the work to be done and the reasons for it and include the following information:

- a. total estimated cost, including fees, fitting out and VAT;
- b. spread of costs over financial years;
- c. contributions from sources other than the grant-in-aid;
- d. implications of the project for future maintenance and running costs, and the proportion of such costs to be met from sources other than the grant-in-aid.

Approved Grant-in-Aid

10. The OAL shall send to the Museum as soon as possible each year a formal statement of the grant-in-aid allocated for the next three financial years. The amounts notified will be subject to parliamentary approval on an annual basis, and will represent cash limits.

11. The OAL shall specify the amounts within the grant-in-aid which are to be used for the enhancement of the collections, for running costs and for building and maintenance work, and as necessary for any other specific purposes. The Museum shall make proposals to the OAL if there is any need to spend, during the financial year in question, sums in excess of those specified, within the overall allocation. Such proposals will be considered on merits.

Expenditure Plans and Profiles

12. The Museum shall submit to the OAL, by a date and in a format agreed with them:

- a. a budget or plan showing the intended application of the grant-in-aid allocation and other income for the financial year beginning on the following 1 April;
- b. separate profiles of forecast expenditure by month on running costs, and building and maintenance work for the financial year beginning on the following 1 April. The profile of building and maintenance expenditure shall show separately the main categories of expenditure, and the expenditure forecast on any project costing in total £250,000 or more.

Approval to Incur Expenditure

13. Enhancement of the collections, running costs and minor building and maintenance works. Except as provided elsewhere in this Memorandum, the Museum may, without further reference to the OAL, incur expenditure on the enhancement of the collections running costs and minor building and maintenance works (costing under £250,000) within approved plans, and apply income from non-Exchequer sources together with grant-in-aid for these purposes.

14. Major building and maintenance projects. The Museum shall not proceed with detailed design work on building or maintenance projects costing £250,000 or more until it has the approval of the OAL (see paragraph 9). The Museum shall seek the OAL's further approval on the basis of a proposal and appraisal updated as necessary, before going out to tender on any such project or part of it. The Museum shall inform the OAL at any time if a significant change arises in one or more of the key assumptions, including cost and time, on which a project has received approval. If the forecast cost of any major project exceeds the original estimated cost by 10% after allowing for inflation on a basis to be notified, the Museum shall seek the approval of the OAL to continue with the project.

Payment of Grant-in-Aid

15. Enhancement of the collections. The OAL shall pay instalments of grant-in-aid for purchases on request. The total amount of purchase grant-in-aid held by the Museum, including any balances carried over from previous years, will be notified to the OAL annually, or on request.

16. Running costs. Unless otherwise agreed, the grant-in-aid for running costs shall be paid on request in monthly instalments to meet the net payments expected by the Museum, having regard to any cash balance available. In the last month of the financial year the full amount outstanding shall be paid on request.

17. Building and Maintenance Work. Unless otherwise agreed, the grant-in-aid for building and maintenance work shall be paid on request in monthly instalments to meet the net payments by the Museum,

*26 March 1991]**[Continued]*

having regard to the forecast profile provided by the Museum in accordance with paragraph 12b and updated quarterly, and to any cash balance available.

18. General – requests for instalments of grant-in-aid shall be submitted in a form prescribed by the OAL and shall include a signed certification by an authorised official of the Museum in the following terms:

“I certify that the conditions applying to the grant-in-aid have been duly observed in the expenditure of money received to date.”

19. Cash balances during the year shall be held at the minimum consistent with efficient operation. In order to avoid unnecessary issues from the Exchequer, the Museum shall collect due receipts promptly and shall not pay invoices before they are due. All matured and properly authorised invoices must be paid as quickly as possible, although benefit of credit terms offered by suppliers should be taken wherever practicable.

20. Any part of the grant-in-aid provision in respect of a particular financial year which has not been paid to the Museum by 31 March in that year, shall lapse.

Carry-over

21. Any balance of the grant-in-aid for the enhancement of the collections, which has been issued but remains inspent at the end of the financial year, may be carried over into the next year. The Museum may carry over from one financial year into the next any unexpended balance up to a limit of 2% of the authorised grant-in-aid issued for running costs, and up to a limit of 2% of the authorised grant-in-aid issued for building and maintenance work.

22. With the agreement of the OAL, any unspent receipts may be carried over into the next financial year for application to specified purposes.

23. Any unexpended balance of issued grant-in-aid above the limits in paragraph 21 or any receipts to which paragraph 22 does not apply, shall at the end of the year be surrendered to the Exchequer or taken into account against grant-in-aid payments for the succeeding year, as the OAL shall determine.

Monitoring Expenditure

24. The Museum shall at all times closely monitor income and expenditure, and ensure that it remains within the cash limit of the grant-in-aid in each financial year. The OAL should be informed at once if it becomes apparent at any time that an overspending or underspending of the approved Estimates is likely to occur.

25. For Vote accounting purposes the Museum shall supply, at such times and in such manner as the OAL may require, financial information relating to expenditure and outturn.

26. Building and Maintenance Expenditure. The Museum shall comply with such requirements as may be notified by the OAL for information concerning the Museum's payments and commitments in respect of building and maintenance work.

Accounts

27. The Museum Accounting Officer will keep proper accounting records to meet the requirements of the relevant statutes and of the OAL. He will maintain instructions for that purpose. In drawing up the accounts, the Museum shall have regard to the guidance in the joint Cabinet Office (MPO) and Treasury publication “Non-Departmental Public Bodies: a Guide for Departments” (NDPB Guide), or successor documents, in respect of the disclosure of information.

28. accounts shall give a true and fair view of:

- a. the state of the Museum's affairs at the end of the financial year; and
- b. all income of the Museum (including that from central government, from activities wholly or partly financed from the grant-in-aid, from trust funds held by the Trustees and from trading companies, funds or other organisations in which the Trustees have, ex officio, a financial or managerial interest) and all expenditure for Museum purposes from that income during the financial year.

29. The Museum shall close its books as soon as possible after 31 March. The draft statement of accounts of the Museum shall be submitted to the OAL as soon as is practicable after the books are closed, and not later than 31 May.

30. The Museum's Accounting Officer shall sign and submit by an agreed date each year the final statement of accounts of the Trustees in relation to the financial year immediately preceding, in the form set out by the OAL with the approval of the Treasury. The statement of accounts shall be transmitted to the Comptroller and Auditor General to be examined, certified and laid before Parliament.

31. The accounts specified above, and the books, documents or papers of the Museum that relate to the accounts, shall be open to inspection by the Comptroller and Auditor General and other persons so

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[Continued

authorised by the Minister. The Comptroller and Auditor General may carry out examinations into the economy, efficiency and effectiveness with which the Museum had used its resources in discharging its functions.

Finance—General

32. The Museum shall comply with any relevant recommendations of the Public Accounts Committee or other Parliamentary authority, which are accepted by the Government, whether specific to the Museum or of more general application.

33. The Museum shall:

- a. introduce and maintain to the satisfaction of the OAL an appropriate system of financial management in the light of the guidance given in the NDPB Guide (in particular Chapter 9), or successor documents;
- b. comply with such other relevant guidance on the administrative practices relating to the expenditure of public funds as are mentioned in Appendix J of that publication or are otherwise notified by the OAL, in particular that given by “Government Accounting”, as amended or augmented from time to time;
- c. inform the OAL of the system they introduce and of any subsequent significant changes in it; and
- d. provide adequate access to, and collaborate with, the OAL in the conduct of periodical financial reviews, including financial management surveys.

34. A list of detailed financial requirements is at Annex B.

Contracts

35. All purchases of works equipment, goods and services shall be based on value for money, ie quality (or fitness for purpose) and delivery against price. Contracts should be placed on a competitive basis unless there are good reasons to the contrary. Where practicable at least three quotations shall be obtained for contracts in excess of £3,000 and steps taken to appraise the financial standing of potential contractors. Advice on the application of these principles is contained in the Treasury’s Revised Consolidated Guidelines on Public Purchasing Policy (PPC(87)1). Tendering procedures shall be in accordance with any additional guidance issued by the OAL. For contracts involving expenditure of £250,000 or more, the Museum should not take single tender action without the prior agreement of the OAL.

Staffing

36. Within the limits of the authority separately delegated to it by the OAL in respect of the creation or re-grading of posts, the Museum may employ staff in such numbers and grades as it thinks fit.

37. Except where previously authorised by the OAL, the provisions of the Civil Service Pay and Conditions of Service Code, and the Establishment Officers’ Guide, shall apply to the terms and conditions of the Museum’s staff.

38. The Museum shall furnish in the corporate plan or separately details of the staff complement and the staff in post, by grade, at the beginning of the current financial year (1 April), and forecasts of the complement for the five succeeding years.

39. The OAL may, from time to time, after consultation with the Museum, initiate management reviews, staff inspection and organisation and methods, or similar, reviews. Draft reports will be discussed with officers designated by the Museum to ensure factual accuracy. The OAL will expect the Museum to implement the recommendations of final reports where these have been agreed with the OAL and the Museum.

Information

40. The Museum shall provide the OAL with such information as it may from time to time request, about the organisation and operation of financial control and of its effects, including the application to Museum purposes of capital or income from trust funds held by the Trustees and from trading companies, funds or other organisations in which the Trustees have, ex officio, a financial or managerial interest.

Failure to Comply

41. The OAL may reduce or withhold grant-in-aid if any condition or requirement set out in this Memorandum is not fulfilled.

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[Continued

Revision

42. In consultation with the Museum, and with the concurrence of the Treasury as appropriate, the OAL may from time to time revise, revoke or add to any of the grant conditions in this Memorandum. Its terms will be reviewed in September 1989.

Interpretation

43. Questions arising on the interpretation of any statement in this Memorandum shall be resolved by the OAL after consultation with the Museum and the Treasury, as appropriate.

Effective Date

44. These arrangements shall take effect from the financial year beginning 1 April 1988.

March 1988

ANNEX A (to A)**DELEGATED AUTHORITIES IN RESPECT OF DEFINED LOSSES, SPECIAL PAYMENTS, ETC**

1. The Museum shall maintain details of, and record in its accounts, the Defined Losses and Special Payments in the categories prescribed in the Schedule in Section M of Government Accounting.

2. The Museum's Accounting Officer shall have full delegated authority to write off such Defined Losses and make such Special Payments, but any case involving a sum of £5,000 (£1,000 if fraud is suspected) shall be immediately reported to the Office of Arts and Libraries. All cases of fraud by Museum staff shall be investigated, and a report made to the Director.

3. Any novel or contentious payments shall also be reported to the Office of Arts and Libraries.

4. OAL approval shall be obtained before any extra-statutory payment is made.

ANNEX B (to A)**SUPPLEMENTARY GUIDANCE**

The Museum shall ensure that:

- a. an effective internal audit is maintained, and that accounting and other procedures contain all reasonable safeguards against theft and fraud;
- b. any grants made to other organisations are accompanied by appropriate conditions to enable the books and records of such organisations to be available, to the Comptroller and Auditor General, and to the Minister;
- c. there are arrangements for adequate inventories to be held, giving sufficiently detailed information in respect of the objects, stores and equipment which it holds, and adequate stock and stores accounts, kept;
- d. the Museum shall seek the OAL's approval before authorising any information technology project exceeding the OAL's own delegated limit from the Treasury. The OAL will inform the Museum of current limits.
- e. it has the approval of the OAL to any proposal to acquire or dispose of land or buildings. The proceeds from any such disposal shall be surrendered to the Exchequer unless other arrangements are agreed with the OAL and the Treasury.
- f. capital assets or equipment (other than buildings of land (see e above) or objects from the collections in their care) that are valued at over £5,000:
 - i. shall not be disposed of without the consent of the OAL; and
 - ii. the proceeds of the sale shall be surrendered to the Exchequer, unless other arrangements are agreed by the OAL.
- g. a record of all losses, whether within delegated powers or not, of cash, equipment, stores, abandoned claims, etc., is kept, and all losses sustained are suitably recorded in the statement of accounts for each financial year;
- h. the prior approval of OAL is sought for all cases falling outside the Museum Accounting Officer's delegated authority set out in Annex A to this Memorandum.

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[Continued]

- i. except where there are statutory requirements or other obligations in circumstances recognised in general by the OAL, the usual rule of non-insurance is followed, and any proposal for departing from it is referred to the OAL;
- j. except where agreed with the OAL, fees paid to consultants do not exceed such rates as are provided for in the Civil Service Pay and Conditions of Service Code, and the Establishment Officers' Guide, or, where scale fees for professional services do not apply, that the contract tendering procedure is followed;
- k. that it does not borrow or lend money, or charge any asset or security, without the consent of the OAL, which may be subject to conditions;
- l. indemnities are neither offered nor accepted in respect of loans of objects to or from the collection, except in accordance with conditions laid down by the OAL;
- m. no guarantee or indemnity is issued, except under sub-paragraph l. above, nor any other contingent liability incurred (whether or not in legally-binding form) without the approval of the OAL, given with the consent of the Treasury;
- n. its banking arrangements are efficient and economical.

Annex B

THE NATURAL HISTORY MUSEUM CORPORATE PLAN 1990-95

SUMMARY

In this Corporate Plan, the Museum has taken the opportunity to reappraise and redefine its role and position in the market place.

A new mission statement supported by clear objectives has been established. A positive strategy for achieving the objectives has been defined which:

- (a) establishes a new management structure for curation and focuses taxonomic research on a series of programmes concerned with environmental, human wealth and human health issues
- (b) allows for the completion of a major programme of 8 new permanent exhibitions by use of contracting out of design and production
- (c) concentrates, to a greater degree, educational resources on the needs of the new National Curriculum
- (d) improves customer care and visitor facilities, with the establishment of new Front of House teams and greater emphasis on exhibition maintenance and
- (e) provides for the continued maintenance and improvement of the Museum's estate and the unavoidable replacement of the collection store at Ruislip.

Full achievement of the strategy will require:—

- (a) additional funds from OAL, including the provision of a replacement store for collections
- (b) a reduction in fixed costs mainly by reducing the number of permanent staff
- (c) increasing self-generated income to 30% of the total budget by 1994-95
- (d) the maintenance in real terms of OAL's Running Costs Grant-in-Aid. On the assumptions used in the plan this would require an additional £4.4m over four years and
- (e) redeployment of resources across most of the Museum's activities.

The achievement of the objectives set out in this Plan will create the flexibility necessary for the Museum to maintain and strengthen its position among the leading natural history museums of the world, and improve the value for money given to our audiences, within the resources likely to be available.

1 INTRODUCTION

1.1 The Museum has now been on its present site for over 100 years during which its collections have expanded to become the most important in the world with a present holding of over 67 million specimens. In addition the NHM houses the largest natural history library in the world and the third largest collection of art on paper in the UK. Together these constitute a considerable part of the nation's scientific and cultural heritage.

1.2 But the Museum is not and never has been solely a "reference collection". It has for many years played an important role in the teaching and understanding of natural history through its research, education and exhibition programmes. In total it is recognised as making a unique and comprehensive contribution to the understanding of natural history which is unmatched anywhere else in the world.

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1.3 With the new and increasing concern about man's effect on the global environment, the Museum's knowledge and expertise are of greater relevance than ever before.

1.4 These new and expanding demands require an organisation which is not only soundly housed and properly resourced in terms both of staff and funding but also one which has a clear and consistent focus for all its activities.

2 THE MISSION

2.1 This focus has recently been redefined in the following Mission Statement:

“To promote the understanding and enjoyment of the variety of our natural world through high quality exhibitions, education and science”

2.2 It gives rise to the following key objectives for the next five years:

(a) Science

- for curation, to increase the efficiency of collection management and associated advisory services.
- for research, to develop basic and applied programmes relevant to contemporary needs and issues.

(b) Library

- to conserve the collections and provide a service to meet the needs of the Museum.

(c) Exhibitions

- to improve the level of maintenance in the galleries.
- to provide a comprehensive series of permanent exhibitions which are up-to-date and relevant to audience needs.

(d) Education

- to complete the development of an educational programme tailored to the needs of the new National Curriculum.

(e) Front of House

- to improve customer care.
- to enhance further the environment and facilities provided for visitors.

(f) Estate

- to maintain the estate to a high standard, particularly by reroofing the Waterhouse Building.
- to ensure the proper housing of collections mainly through the replacement of the Ruislip store.

(g) Management

- to bring about improvements in Museum organisation and management in order to build upon and develop the commitment and skills of its staff.

(h) Resources

- to increase income in real terms, both from Grant-in-Aid, from other sources across all the Museum's activities, and by effective marketing.
- to continue improving the effectiveness with which resources are used.

3 THE STRATEGY

3.1 In order to achieve these key objectives the Museum requires to concentrate its efforts on those activities which are most relevant to its mission and therefore its audiences, and to emphasise those areas where it can maintain and enhance its leadership.

3.2 This requires clear priorities across the whole range of activities and the restructuring of the organisation in key areas. Since the Museum is constrained by resources, it needs to ensure that it has sufficient flexibility in its programme of work to respond to fluctuations in income and changing demands. This requires a reduction in fixed costs.

3.3 The following strategy has been formulated:

Science

- for Curation and advice, the management and organisational structures are being redefined to ensure that resources can be focussed on:
 - (a) continuing a basic level of care and maintenance of the collections,
 - (b) making these materials available to research workers worldwide,

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[Continued

- (c) developing those parts of the collections that are relevant to the Museum's research programmes,
 - (d) providing an effective and efficient advisory service.
- for Research, work is being reorganised into a series of programmes that emphasise the unique and vital contribution the Museum's collections and taxonomic expertise make to issues of contemporary human concern. Six programmes are recognised museumwide:
- Biodiversity
 - Environmental Quality
 - Living Resources
 - Mineral Resources
 - Human Health
 - Human Origins.

A number of smaller programmes appropriate to individual research teams will also be introduced.

All of these programmes will be responsive to changes in audience needs and, by their interdisciplinary nature, will enhance collaboration between the Museum and other national and international organisations.

These initiatives will be supported by a core of curiosity-driven research that is excellent at the highest levels. This work will enable the Museum to maintain its position at the forefront of systematic and taxonomic research.

Library

- Services will be reorientated towards the needs of the curatorial and research activities of Museum staff and income generation. The current conservation programme will be maintained as a high priority.

Exhibitions

- Currently 55 per cent. of the Museum's exhibition space is either empty or houses exhibitions which are over 15 years old. The exhibition programme must be geared not only to providing a comprehensive treatment of the subject but also to a cycle of replacement based upon a maximum life for a "permanent" exhibition of 15 years. The planned five-year programme consists of eight new exhibitions – Dinosaurs, Birds, Wonders of the Living World, Mammals, Minerals & Gems, Wonders of the Earth, The Useful Earth and The Story of the Earth.
- To achieve the objectives for the exhibition programme the Museum will:
 - (a) concentrate in-house resources onto the maintenance of the exhibition galleries by regrouping staff into three multi-disciplinary teams each having complete responsibility for the maintenance and operation of a specific area of the Museum.
 - (b) subcontract the design and production of new exhibitions so that there is the flexibility to cope with fluctuations in the flow of work, the uncertainties of funding and to benefit from the creativity and vigour of independent design companies.
 - (c) mount temporary and travelling exhibitions when additional funding is available.

Education

- Efforts will be further concentrated on new written material and advice to help schools use the Museum's exhibitions and facilities in the teaching of the new National Curriculum.

Front of House

- Facilities for the visiting public will continue to be improved and expanded to meet their needs. Attention will be focussed on improving the general environment in the public areas both inside and outside the Museum (eg lighting, seating and cleaning) to a design consistent with the house style recently developed as part of the Corporate Identity.
- The multi-disciplinary gallery teams will also include cleaning staff and museum guides. The latter will require the reorganisation of the existing warding staff into those whose primary responsibility will be for information giving and those primarily concerned with security. In addition the existing shops, admissions and enquiry desk staff will be managed as a single Front of House team.

Estate

- The recently formed estate team will develop a comprehensive 10 year plan for accommodation and maintenance in parallel with the completion over the next five years of the reroofing of the Waterhouse building and the replacement of the Ruislip store.

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[Continued

Financial Resources

- Efforts to increase income from non-exchequer sources will focus:
 - (a) for the development Trust, on attaining the £5M appeal and further fund raising both through sponsorship appeals and launching a membership scheme for individual and corporate giving.
 - (b) for Commercial activities, on seeking further merchandising opportunities and in shops and publications on operations which are currently being reviewed to increase sales and improve profitability.
 - (c) on Marketing activities which are aimed at enhancing the Museum's corporate image and increasing visitor numbers.
 - (d) on marketing Science by raising the profile of the Museum's work and thereby increasing sponsorship, grants commissioned research and contracts.
- For Grant-in-Aid, on making bids for additions to the building grant to finance the replacement of the store and for Running Costs to maintain the value of the grant in real terms.
- Efforts to improve value for money will centre on:
 - (a) reducing fixed costs thereby allowing flexibility and affordability.
 - (b) redeploying funds to areas of priority, identified above.
 - (c) improving financial management.

Human Resources

- The Museum's single biggest investment is in the people it employs. In order to maximise the return on its investment, and respond to changes in customer needs, the strategy will concentrate on:
 - (a) defining a management structure that will enable staff to be deployed more effectively towards achieving the Museum's objectives.
 - (b) employing a staff size then reconciles the Museum's needs with what is affordable.
 - (c) increasing investment in the training and development of staff.

4 RESOURCES

The strategy above has to be achieved within the resources available. Annex 1 summarises the allocations which the Museum intends to make to its main activities over the next five years. These exclude the additional funds sought from OAL for Running Costs without which the Museum's objectives will not be totally fulfilled.

Detailed below are the present position and future plans for the three key areas of buildings, human resources and finance.

4.1 Buildings

- (a) Over the next five years only one major maintenance project, the reroofing of sections of the roofs of the Waterhouse building is required. Despite the aesthetic delights of occupying a Victorian building, its Grade I listing not only places a statutory obligation on the Museum to continue a high level of maintenance indefinitely, but also restricts the ways in which it can be used. Indeed as a museum the Waterhouse building has been functionally obsolete for very many years.
- (b) The Museum also has a statutory duty to keep its collections within authorised repositories (Section 3(1) of the 1963 Act). The outstation at Ruislip is one such repository and currently 12,000m² of storage space is used there for part of the collections. The lease on the store runs out in 1995 by which time the Museum must have an alternative site. Legally the Museum has no protection and cannot remain on the site. In any case the landlord has already sought the Museum's views on vacating the store before the lease expires. The most economic solution is to replace the storage at Ruislip with a new store built and owned by the Trustees. Under Section 12 of the 1963 Act there is a statutory obligation placed on Parliament to provide for "any increase in expenditure" for additional premises. The additional costs of the store will have to be provided for by additions to the Building grant. There is virtually no flexibility in the grants for 1990-91 or later years.
- (c) Annex 2 sets out details of the building programme for the next five years, which apart from the roofs and the new store, contains mainly projects which are linked to the maintenance of the building or to meet health, safety and fire prevention requirements. The income projections in the plan therefore assume that Government will meet fully these building requirements which are unavoidable. Clearly from what has already been said about running costs there is no scope for diverting funds from that source to meet building costs.

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[Continued

4.2 Human Resources

- (a) The Museum has a history of gradually running down its staffing levels, commensurate with reductions in funding in real terms. 50 posts have been lost since 1983-84. In 1989-90 wage increases significantly exceeded the increase in funding. As a result, 40 posts have had to remain unfilled. Savings through natural wastage rarely occur in ideal places. There is therefore the danger that, if this policy continues, the Museum will become resource-driven rather than directed towards the needs of its audiences.
- (b) In 1989-90 wage costs accounted for 98 per cent of the Grant-in-Aid for Running Costs. The Grant has been significantly increased in 1990-91 reducing wage costs to 92 per cent of the Grant. Nevertheless, this effect will be short-lived if the Grant is not maintained in real terms. By 1992-93 wage costs will be back at 98 per cent of Grant, and by 1994-95, 100 per cent, if existing staffing levels are maintained. This means that all other expenditure, except buildings, would be financed by self-generated income, placing an impossible strain on the Museum.
- (c) Several parts of the Museum's strategy will have a direct impact on the existing staffing levels:
 - in Science, a reducing grant in real terms requires the Museum to "cut its coat according to its cloth". At the same time it will have to inject 'new blood' into priority areas and actively seek external funding to self-finance further appointments.

This necessitates a reappraisal of the priority areas for science and a closer definition of posts and the management structure within the areas of curation and research. Associated with these changes will be the extension of fixed grading for some posts.

- in Exhibitions, there is a need to reduce the level of in-house staff and contract out services in order to respond to fluctuating work loads and funding and import the best creative talent, cost effectively.
 - in Front of House, a shift from traditional warding, to information givers and security, will result in a redeployment of existing staff. In addition, day to day management of cleaning will transfer to the new gallery team managers and the establishment of a single team for the shops admissions and enquiries.
- (d) To summarise, two issues need to be addressed:

flexibility—to respond to changes in audience needs whilst maintaining credibility and vigour.

affordability—to reduce the overall level of staff to one commensurate with its needs and the funding available.

The net effect of meeting these two requirements is to reduce the existing staffing level by 50-60 posts, in addition to the 40 posts which have been saved in 1989-90 through natural wastage. The reduction will be achieved in 1991-92 by natural wastage and redeployment where possible but some voluntary and compulsory early retirement will be necessary.

Underpinning this strategy is a need to increase investment in training and retraining. Staff will then have the appropriate skills to respond to audience demands thereby providing them with better job satisfaction and security for the future.

4.3 FINANCE

- (a) For many years the Museum has had to manage its activities against Government funding which has been reducing in real terms. It was achieved initially by reducing activities peripheral to its main goals and increasing efficiency. In 1986, it recognised that this process in itself was not sufficient and therefore made a positive decision actively to raise funds from the private sector. Hence the decision to introduce admission charges in 1987 and the considerable and successful expansion of its commercial activities over the last four years.

Thus the Museum has:

- (i) steadily increased its turnover and improved profitability from retailing.
- (ii) raised income from merchandising to £0.3 million in 1989-90.
- (iii) produce a mail order catalogue.
- (iv) developed an evening functions business in two years from scratch which will earn a net profit of £0.2 million in 1989-90.
- (v) introduced new and expanded catering facilities and.
- (vi) launched an appeal for the exhibition programme through its Development Trust, in November 1989, which already has pledges of £3.6 million against a target of £5 million over five years.

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[Continued

(vii) increased its surplus from the external funding of science projects to £0.1 million in 1989-90. Overall these income generating activities have increased from 17 per cent in 1987-88 to 25 per cent in 1989-90 of total budget and are planned to increase to 30 per cent by 1994-95.

Self-reliance at this level places the Museum among world leaders. In the comparable case of the Smithsonian Institution's Natural History Museum, 75 per cent. of its funding still comes from Federal and State sources. But success at this high level is not without its problems since the income generated is, by its nature, uncertain. This was starkly demonstrated in 1989-90 when despite staging one of our most successful temporary exhibitions ever, "Dinosaurs Live", a combination of a down turn in the tourist industry, exceptionally good weather and transport strikes, led to a fall in visitors with subsequent loss of income. The Museum must therefore also be able to respond more flexibly to fluctuations in income and this means reducing its fixed overheads.

- (a) Uncertainties over the Grant-in-Aid for Running Costs only add to the need to reduce fixed costs if the Museum's activities are to progress in a planned way. Until 1989-90 the annual fall in the real value of these funds of around 15 per cent. or 25 per cent. has been offset by increases in other income. The high level of pay awards which was outside the Museum's control added to the difficulties in balancing the budget in 1989-90. For 1990-91 and beyond it seems likely that the gap will widen between the annual increases in the Grant-in-Aid and the Museum's projection of cost increases.

OAL has already indicated that increases in Running Costs Grant-in-Aid will be at 45 per cent. per annum for 1990-91 to 1992-93. On the assumption that the annual increase by OAL continues at 45 per cent. for 1993-94 and 1994-95, this compares with the Museum's own projection of inflation as follows:—

		90-91	91-92	92-93	93-94	94-95	TOTAL
Grant-in-Aid	£M	16.9	17.6	18.3	19.0	19.8	
Increase per annum	%		4.0	4.0	4.0	4.0	
Museum projection							
Salary inflation	%	7.5	7.5	6.5	5.5	5.5	
General inflation	%	7.0	7.0	6.0	5.0	5.0	
Requirement to Maintain Grant in Real Terms	£M	16.9	18.1	19.3	20.3	21.4	
Shortfall	£M	—	0.5	1.0	1.3	1.6	4.4

It is crucial that this shortfall of £4.4m is met by OAL, so that the Museum can meet its objectives. It would be allocated to the essential projects listed below over the next five years. Without these projects many of the long term benefits which will accrue from the reorganisation will be lost.

		£M
Science	— Curation, increasing the effectiveness and efficiency of collection storage systems and thereby improving long-term preservation by greater environmental control and increasing accessibility for research workers. This will involve installing compactor systems and using drawers or containers which exclude insect pests and reduce evaporation of liquids.	1.0
	— Research, over the next five years the Museum will contribute to the study of major issues concerned with environmental quality, maintenance of biodiversity and tropical forests. This will require an imaginative response to research problems and will be achieved by making short-term appointments at junior and senior levels.	0.8
Exhibitions	— The revision and updating of existing permanent exhibitions so that the Museum remains an authoritative voice on natural history and maintains its appeal to the general public.	0.5
	— Reinstatement of travelling and temporary exhibitions to reach and attract a wider audience and to enable the Museum to respond quickly to current events.	0.6
Commercial	— Refit shops and invest in new income generating enterprises.	0.5
Support	— The new initiatives being undertaken by the Museum in the fields of science, exhibitions and resource management require more effective information and communications systems. A new computer to aid corporate decision making and a network to link the appropriate areas within the organisation and with external bodies, are required.	0.8
	— Fulfilment of the training programme.	0.2

Annex 1 sets out allocations for expenditure which can be balanced with income over the five years

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taking account of the staff reductions but without the projects listed above. Even so in 1991-92 there is a deficit arising from restructuring costs. This will be met by carrying forward the surplus expected in 1990-91 and deferring expenditure in 1991-92 on capital equipment and if necessary buildings unless OAL are prepared to make a one-off contribution.

5 CONCLUSION

This plan sets out a strategy for the Museum aimed at achieving objectives which have been redefined to meet the needs of audiences and in doing so enhance its position as the leading natural history museum in the World. This will require restructuring across most of the Museum's functions. Within the income likely to be available over the next five years, the plan incorporates a financial and staffing strategy aimed at achieving maximum flexibility and value for money. It also recognises the need for core-funding from Government to be, at least, maintained in real terms.

ANNEX 1

CORPORATE PLAN 1990/91 — 1994/95

	89/90	90/91	91/92	92/93	93/94	(£m) 94/95
1 Income						
Grant in Aid:						
Running Costs	15.4	16.9	17.6	18.3	19.0	19.8
Purchase	.3	.2	.2	.2	.2	.2
Buildings	6.3	8.1	8.6*	8.9*	7.5	6.2
Total Grant in Aid	22.0	25.2	26.4	27.4	26.7	26.2
Self-Generated:						
Commercial:						
Shops & Publications	2.2	2.5	2.8	3.1	3.4	3.7
Catering	.1	.1	.1	.1	.1	.1
Functions	.4	.5	.5	.6	.6	.6
Total Commercial	2.7	3.1	3.4	3.8	4.1	4.4
Front of House (Admissions)	1.5	2.1	2.2	2.4	2.5	2.7
Curation & Research	.1	.4	.6	.7	.9	1.0
Development Trust	.1	1.0	.8	.8	.7	1.2
Buildings (Shared Services)	1.8	1.8	1.9	1.9	2.0	2.0
Other	.9	1.0	1.0	1.0	1.0	1.0
Total Self-Generated	7.1	9.4	9.9	10.6	11.2	12.3
Total Income	29.1	34.6	36.3	38.0	37.9	38.5
2 Expenditure						
Commercial:						
Shops & Publications	1.6	2.1	2.2	2.4	2.6	2.9
Functions	.2	.2	.2	.2	.2	.2
Total Commercial	1.8	2.3	2.4	2.6	2.8	3.1
Front of House	2.5	2.7	2.9	3.1	3.2	3.4
Exhibitions	3.5	5.3	4.8	5.1	5.5	5.9
Development Trust	.0	.1	.1	.1	.1	.1
Marketing	1.1	.7	.8	.8	.8	.9
Curation & Research	7.6	8.4	8.6	9.1	9.5	9.9
Library	1.5	1.5	1.4	1.5	1.6	1.7
Directorate	.2	.3	.3	.3	.3	.3
Support Services	2.8	3.1	3.6	3.9	4.1	4.3
Buildings	8.1	9.9	10.5	10.8	9.5	8.2
Restructuring Costs	.0	.0	1.8	.4	.4	.4
Total Expenditure	29.1	34.3	37.2	37.7	37.8	38.2
3 Surplus (Deficit)	.0	.3	(.9)	.3	.1	.3

* Includes additional funds required for new collection store at £1m p.a.

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		NOTES TO CORPORATE PLAN					
		89/90	90/91	91/92	92/93	93/94	94/95
1	Income						
	Grant in Aid:						
	Running Costs:						
	Notified	£m 15.4	16.9	17.6	18.3		
	Bid For	{£m				19.0*	19.8*
		{£m		.5†	1.0†	1.3†	1.6†
	Total	£m 15.4	16.9	18.1	19.3	20.3	21.4
	Purchase Grant:						
	Notified	£m .2	.2	.2	.2	.2	.2
	Bid For						
	Total	£m .2	.2	.2	.2	.2	.2
	Building Costs:						
	Notified	£m 6.3	8.1	7.6	7.9		
	Bid For	£m		1.0‡	1.0‡	7.5	6.2
	Total	£m 6.3	8.1	8.6	8.9	7.5	6.2
2	Expenditure						
	Salaries	£m 15.1	15.6	15.2	16.1	17.0	18.0
	% Grant in Aid	98%	92%	86%	88%	89%	91%
	% Total Expenditure	72%	64%	57%	60%	60%	60%
	(exc building & restructuring costs)						
3	Headcount						
	(Full time equivalent)						
	Start of Year	820.0	780.0	781.5	726.5	724.0	724.0
	Net Changes	-40.0	1.5	-55.0	-2.5	0.0	0.0
	End of Year	780.0	781.5	726.5	724.0	724.0	724.0
4	Inflation Assumptions						
	Wages		7.5%	7.5%	6.5%	5.5%	5.5%
	General		7.0%	7.0%	6.0%	5.0%	5.0%
5	Notes						
	* Assumes that 4% uplift continues.						
	† Assumes grant is maintained in real terms.						
	‡ For replacement store.						

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ANNEX 2

FIVE YEAR BUILDING PROGRAMME

	90-91	91-92	92-93	93-94	£'000 94-95
1 PSA (ongoing)					
East Basement	250	—	—	—	—
High Voltage Ring Main	182	—	—	—	—
Fire Officer's Requirements	48	150	—	—	—
Waterhouse Roofs (SE Pavillion)	538	—	—	—	—
Tring Roof	10	—	—	—	—
plus carry in from 1989-90	500	100	—	—	—
less carry out to 1991-92	(100)	—	—	—	—
	1,428	250	—	—	—
2 NEW WORKS					
Ruislip	1,200	2,000	3,000	1,500	—
Baby Changing facilities	28	—	—	—	—
GM Fire Escape	100	200	—	—	—
Waterhouse Roofs (West)	1,000	500	—	—	—
Spirit Building Electrics	300	—	—	—	—
DNA Laboratory	10	—	—	—	—
Fire Officer's Requirements	100	200	200	—	—
Rationalise Accommodation	100	200	700	800	1,000
Collection Storage	—	150	—	—	—
Car Parking	—	25	—	—	—
Gardens	50	—	—	—	—
Electrical Rewiring	75	—	—	—	—
Lift Overhauls	75	100	100	100	100
Galleries refurbishment	50	100	100	200	200
Common Room/restaurant for staff and friends of Museum	—	200	—	—	—
Front of House	290	—	—	—	—
Waterhouse Roofs	—	900	700	—	—
New Project Contingency (to include improved laboratory facilities)	—	200	500	1,000	1,000
Tring Roof	150	150	—	—	—
Tring Library	—	30	—	—	—
Tring Toilets	20	—	—	—	—
	3,548	4,955	5,300	3,600	2,300
3 MAINTENANCE & SERVICES					
South Kensington	1,030	1,210	1,340	1,500	1,650
Tring	110	120	130	140	154
Ruislip/Cricklewood	33	37	40	44	150
Utilities	962	1,012	1,063	1,115	1,170
Rents	340	340	340	340	—
Consultants	100	100	100	110	110
	2,575	2,819	3,013	3,249	3,234
4 SALARIES	550	594	632	667	704
TOTAL	8,101*	8,618	8,945	7,516	6,238

* Totals net of Boiler House Services provided for the V & A, Science Museum and Imperial College.

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Annex C**Letter from the Minister for the Arts to Sir Walter Bodmer FRS, Chairman of the Trustees, Natural History Museum.****Grant-in-Aid: 1991/92 to 1993/94**

I am announcing today my provisions for the arts programme for the coming three years. I attach a copy of my statement. I am writing to let you know your detailed allocations for 1993/94 and your revised grants-in-aid for 1991/92 and 1992/93. These are as follows:

	1991/92	£m 1992/93	1993/94
Running Costs	18.966	19.551	20.103
Purchase Grant	0.190	0.190	0.190
Building & Maintenance	8.620	8.900	7.500
SUB TOTAL	27.776	28.641	27.793

These are subject to Parliamentary approval at the appropriate time.

The funding announcement made at this time last year included significant increases across the three years of the settlement to 1992/93 over the figures announced in November 1988. This took account of higher than expected levels of inflation which had been experienced up to that time. I am well aware that museums and galleries are still experiencing difficulties as a result of the pressures caused by rising costs. I have, therefore, thought it right, in consultation with my colleagues in the Treasury, to review further the allocations announced last November. As a result of this review, I have been able to increase again the allocations to the National Museums and Galleries for running costs in 1991/92 and 1992/93 alongside my consideration of the level of resources necessary for the new third year, 1993/94.

These new figures have resulted from difficult negotiations against the background of the Government's overriding need to restrict public expenditure and control inflation. They should be regarded as firm and apart from the distribution of some unallocated reserves of building and maintenance in 1992/93 and 1993/94, I do not anticipate reconsidering them unless further exceptional and substantial changes occur which cannot be foreseen today.

RUNNING COSTS

I am aware of the difficulties which institutions have experienced in meeting centrally-negotiated pay increases. Accordingly, I have again this year made increases in running costs provision to help tackle these problems. I have also taken specific account in the allocation to the NHM of the points you put in your 1990 Corporate Plan, and of the additional costs which will face you as a result of a recent revised Customs and Excise ruling on VAT. I expect all museums and galleries to ensure that their staffing and management systems are efficient and fully responsive to changing needs. You should continue to consider what use can be made of the increased scope for flexibility in terms and conditions of employment and for local negotiation now incorporated within the Civil Service pay system.

Your running costs allocation includes an element of £0.739 million in 1991/92, £0.555 million in 1992/93 and £0.569 million in 1993/94, in respect of the contribution in lieu of national non-domestic rate hitherto paid directly by the Government. My officials will be providing guidance to your Director on the use of this element.

BUILDING AND MAINTENANCE

I have given priority on this occasion to tackling running costs problems and I am therefore not making general increases in buildings and maintenance allocations in the 3 years of the settlement but, in taking note of the priorities set out in Corporate Plans, I am making special allocations to particular NMGs in certain years.

For 1991/92 and 1992/93 I have allocated an additional £1.0 million in each year to assist you with the provision of storage facilities in replacement of those at South Ruislip. You will be pleased to note that I have been able to meet your bid of £7.5 million for building and maintenance in 1993/94 in full.

I am at this stage retaining unallocated sums of £3.35 million for 1992/93 and £4.0 million for 1993/94 from my overall provisions for building and maintenance for museums and galleries in those years. I shall be considering in due course the allocation of these sums.

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[Continued

Purchases for the Collection

As Richard Luce did last year, I have considered very carefully whether increases should be made in the purchase grants of the NMGs. I have concluded, from Corporate Plans and other statements of priorities, that all available resources for the NMGs should be allocated to their priority concerns on running costs and on building maintenance. I have, however, in conjunction with the Secretary of State for the Environment, been able to give some additional resources to the National Heritage Memorial Fund, which should permit it in turn to pass on further help for certain purchases.

Corporate Plans

I am appreciative of the work which institutions have put into preparing their Corporate Plans. I believe they are now, on the whole, very valuable and informative documents which set out clear objectives and priorities. I should be grateful if you would now review your plans in the light of the allocations I have announced today and of other developments, and let me have by the end of March 1991 your plan for the five years beginning 1991/92. My officials have already discussed with your Director the format and desirable contents of the Plan and I should be grateful if you would take that discussion into account in your review.

On this occasion, I would like to see your Plan include a statement about your institution's policies towards staff training, the resources to be devoted to this subject area and how successful you have been at meeting targets. In addition, I would like you to include a statement covering your institution's services and activities in relation to the wider museum community advisory services to non-national museums.

You should also indicate what changes, if any, have been made in the management of your building and maintenance programmes in response to the Review of Building Management Arrangements which was circulated earlier this year.

Other points which should be covered in the Plan include the setting of targets for key areas of activity and the measures proposed to assess performance against those targets, together with a report on progress. In this, the Plan should take account of the outcome of the review of performance indicators which my Office has been conducting in conjunction with the Consortium of NMG Administrators.

It will be necessary for your Plan, as before, to identify specifically the bid you wish to make for grant-in-aid in the new third year—1994/95. I expect this to be a realistic assessment of your overall needs given the likely continued restraint required on public expenditure. Finally, the Plan should include indicative figures for grant-in-aid needed in 1995/96; these should highlight in particular any special factors likely to lead to an increased or decreased need for grant-in-aid in that year.

I am sending a copy of this letter to Neil Chalmers.

David Mellor

9 November 1990.

Annex D

NATURAL HISTORY MUSEUM
FUNDING AND INCOME ANALYSIS
1985-86 ONWARDS

£M	<i>Grant-in-Aid Running Costs</i>		<i>Grant-in-Aid Building Costs</i>		<i>Self-Generated Income</i>	
	Actual (a)	1990/91 Prices	Actual (a)	1990/91 Prices	Actual (a)	1990/91 Prices
			Prior to 1 April 1988 payment was made by Property Services Agency and figures for individual institutions are unavailable.			
1985/86	11.225	15.064			1.450	1.946
1986/87	11.597	15.041			1.902	2.467
1987/88	12.176	15.001			3.586	4.418
1988/89	12.859	14.736	5.786	6.631	3.911	4.482
1989/90	13.211	14.235	5.863	6.317	4.600(e)	4.956
1990/91(b)	14.856	14.856	7.693	7.693	6.800(e)	
1991/92(c)	16.068		8.203(d)		7.200(e)	

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MR CHARLES HENDERSON

[Continued

£M	Grant-in-Aid Running Costs		Grant-in-Aid Building Costs		Self-Generated Income	
	Actual (a)	1990/91 Prices	Actual (a)	1990/91 Prices	Actual (a)	1990/91 Prices
1992/93(c)	16.783		8.473(d)		7.900(e)	
1993/94(c)	17.239		7.062			

SOURCES (a) Appropriation Accounts 1985/86—1989/90.

(b) Ministerial Statement 16 November 1989.

(c) Ministerial Statement 9 November 1990

(d) 1991/92 and 1992/93 include an additional £1 million pa towards the provision of replacement storage facilities.

(e) Natural History Museum Corporate plan 1990/95 (excluding income from shared utility services provided to other institutions by the NHM).

excluding transfers for superannuation and other services made on 1 April 1988. Also excluding transfers for superannuation and other services made on 1 April 1988. Also excluding from 1991/92 onwards additional transfers made in respect of the contribution in lieu of national non-domestic rates.

Examination of witness

MR CHARLES HENDERSON, Head of Office of Arts and Libraries, called in and examined.

Chairman

1. Thank you for coming and sending us your statement about how the corporate planning arrangements are carried out for the Natural History Museum and the accompanying papers. I believe you have received a list of the questions?

A. Yes.

2. If you are agreeable, it occurs to us that possibly the easiest way is to begin by asking you whether you would like to make a general statement and then perhaps deal with the questions seriatim. How would you like to do it?

A. I think that having placed the note on the table I do not think I need to make a statement. I am quite happy to go through the questions, even if I am given the opportunity to say one or two things which are not directly in answer to the question. I am sure you will draw out from me by your questions everything you want to know and what I would want to tell you.

3. Let us start with the central question: What is the amount of money that goes strictly into scientific research in the NHM, and how does the OAL assess the validity of that part of their activity in attracting funds from you towards general running costs, as distinct from capital?

A. The figure that the corporate plan displays for curation and research is about 50% of the grant in aid for running costs. It is running at about £9m. It was £7.6m in 1989/90 and runs up to £9.9m in 1994/95. That is the figure in the corporate plan. We do not earmark funds going to museums and galleries except as between buildings and maintenance and basic running costs. There is a separate item for acquisitions. We would not see it as part of our responsibilities to say, "You must spend so much on curation and research", or that they are clearly spending too much or too little, unless there was something quite extraordinary about the figures presented to us. In our view, it is the responsibilities

of the trustees and management of the museum to take the decisions which relate basically to the day-to-day running of the museum. We do not have the expertise to second-guess their expertise. That is common across all our museums and galleries; it is not peculiar to science, although I must say that that position is unusual in that it is the only one with a major research programme that we fund.

4. I notice that in the actual spend and also the projected spend there is very little cash increase; it has been of the order of 3 per cent per annum, though there has been reference made in November 1989 and 1990 to a review of expenditure. Did that lead to an uplift in funds?

A. This is taking us to the three-year funding arrangement. Yes, it did. The settlement made in 1987 ran for the years 1988/89, 1989/90 and 1990/91. I think I am right in saying that that was rolled forward in 1988, and in 1989 it was not only rolled forward another year but the figures for the remaining two years of the previous rolling forward were reviewed, in common with all museums and galleries. Recognising there had been unforeseen increases in inflation and other costs, it was uplifted. The figure for the NHM was 11 per cent for running costs and 16% overall.

5. Are those figures given within the plan which the museum itself puts forward? Have they been normalised to reflect actuals or real terms?

A. That is money. The corporate plan which you have reflects that uplift. That was presented to us in April 1990. There was a further review in the 1990 PES round which gave rise to another increase in years one and two, again to reflect unforeseen inflation.

6. You are probably aware there has been a good deal of public concern about the museum expressed by scientists well outside the museum. Obviously, some of that complaint has been orchestrated. The

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MR CHARLES HENDERSON

[Continued

[Chairman Cont]

Committee is concerned to discover whether or not there is any real validity in that. I imagine you must have considered it. In relation to the funding and strategy of the museum, what is your view about that?

A. We were obviously concerned by the extent of scientific concern that was being expressed both in newspapers and correspondence with the Minister, and indeed in the House. We felt it was right for the museum to concentrate on its priorities and not try to do too much with the resources it had. A concentration was bound to give rise to some areas of science of lower priority either being dropped or being given much less prominence in their research programme. It was obvious that scientists in those fields would be concerned this was happening and would say so. It was to be expected that we would get quite a lot of concern being expressed. What we felt it right to do, consistent with what I said earlier about our not having the necessary expertise, was satisfy ourselves that the processes the museum had gone through in arriving at the decisions it took in relation to priorities were rational and sensible, and also to satisfy ourselves that the museum was ready to listen to what was being said to it. Obviously, we let them know what was being said to us. We had a number of meetings with the museum in which we were able to tell them the weight of opinion coming in by way of correspondence, and for them to explain what their responses were to those complaints. The important thing as far as we were concerned was our understanding that the museum had gone through quite a considerable process of consultation, both within the museum and with peer group scientists outside, before it published its plans: and after, to get further feedback, it had a seminar in June of last year. We facilitated their meeting with scientific advisers from the main government departments involved in research and science and the ABRC, and indeed meeting the Chief Scientific Adviser, Professor Stewart. We were able to satisfy ourselves that they had canvassed opinion pretty thoroughly and were plugged into government's other funders of research in a way which should have led to people with the requisite expertise to plan for any fundamental difficulties emerging. We certainly have been assured by the museum that they intend to be flexible in their programme, recognising that opinions can develop and fashions change and this is not something set in concrete. Nonetheless, this is what they consider, in the light of careful consultation, is the right basic strategy today.

7. You mentioned funds coming from other government sources. Is it the position that the OAL in funding the Natural History Museum would ignore what other sums had been obtained from other sources? I notice in the corporate plan, looking ahead over the next five years, that they are expecting to raise something over £4m in the final year. I do not know how much of that comes from research grants and contracts from government departments and research councils, but if it were to be a sizeable sum would that cause the Office of Arts and Libraries to say, "Well, perhaps their grant should be reduced"?

A. To the specific and also to the general question the answer is no. We encourage all our museums and

galleries to do what they can to diversify sources of funding and increase their resources by sponsorship and trading. If they wish to impose admission charges they can do so. We do not have a firm policy on that one way or the other. To the extent they are successful we would look to the museum to use that as an additional resource over and above the grant in aid, not substituting for it in any way. As far as research goes, in the current year they are expecting to earn about £1m in external funding from a wide range of sources. That is further evidence of a very creditable performance in terms of external fund-raising. When it comes to how much they are earning from research in terms of their external funding operations, or for that matter how much they might get by sponsorships for conservation or exhibitions, it is a matter for the museums to decide what their priorities are. We would not take that into account at all in setting the overall budget.

8. In that context, they are a little bit like the universities. You are satisfied that you want to have a well-found laboratory from which, for example, successful applications can be made to other bodies?

A. We certainly want to see that, and we believe they are moving in that direction.

9. You see their accounts annually and presumably the management accounts at any rate are subdivided and show where the money goes?

A. Yes.

10. You would become concerned if the research fraction went down very significantly?

A. Yes. I would become concerned if it was evident their ability to raise funds from outside generally was going down, and obviously if it appeared to be one particular area the concern would be focused on that particular area.

11. As I understand it, in the corporate plan there are six areas set out, and they include human health, biodiversity and so on. In making its grant to the trustees does the Office of Arts and Libraries in a sense implicitly approve those broad areas, or does it just accept that that is what the trustees want to do and therefore they are good things to do?

A. We would not explicitly approve it. We do not approve the corporate plan as such. We would comment on it if we felt it required to be commented upon. We provide that funding, which we consider in the light of the presentation of the corporate plan and the resources available to be what they need, with guidance on how it should be used if we think further guidance is needed.

12. In that corporate plan the trustees make a good deal of the fact that they are the holders of a listed building and that imposes on them certain responsibilities which they cannot avoid with regard to the maintenance of the building. Is that element of their finances in a sense treated separately, because if it were not one could see they would have great difficulty in running the place?

A. Building and maintenance costs are earmarked in a separate fund, and that figure tends to fluctuate depending on the particular building works that they have got in hand. It may be quite lumpy. They have been doing a lot on the roof of the South Kensington Museum which has affected the figures. They are

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MR CHARLES HENDERSON

[Continued

[Chairman Cont]

going to have to replace their store which has required us to increase the provision for that in the next few years.

13. On the whole, you try to take account of the lumpiness in their budget through capital expenditure of this kind?

A. Yes.

Lord Flowers

14. I want to ask a question about how you do your sums. Presumably, you do not have as much money as the museums, galleries and libraries ask for in total, so at the end of the day you have to decide how much to give to each. How do you do that? Do you do it by formula or by judgment? If it is done by judgment do you have advice as to how to exercise that judgment?

A. You are right in your premise that there is never as much money as the museums and galleries would like. To an extent, we have to be influenced by what we know they have to pay for, unless we are expecting them to make major surgery. Staffing is a very large part of most museums' running costs. Most of their running costs are driven by inflation. To the extent we are able to meet what look like being those costs extended into the future with something left over, then we have quite a bit of flexibility to consider where we would want to give more or less emphasis. We do not take expert advice as a matter of routine in relation to that. Obviously, we go through all the corporate plans and bids of museums and galleries with them. We have quite an in-depth discussion of what their priorities are and how important timing might be for the additional spend they are bidding for. Obviously, we are aware of the particular areas in which they are involved. Our judgment would tend to be influenced by, for instance, whether or not there is a major additional running cost or responsibility coming on to their shoulders. For example, following the opening of the new wing of the National Gallery, that body has had to plan for quite a considerable increase in staffing. Obviously, that was something to which we had to give priority. We would give priority to expenditure which looked as if it was consistent with some policy we were generally pursuing related to financial management initiatives, cataloguing, conservation and so on. Otherwise, if one was considering any flexibility one might have thereafter, one would be influenced by the quality and pressing nature of the particular projects.

15. But if some of those projects are research projects, how do you judge the quality of them if you do not take expert advice and you claim not to have such expertise yourself?

A. That might be a case. I cannot recall our being confronted with that proposition. Research is not something which has prominently featured in extra bids by museums and galleries. All of them wish to continue with their research programmes.

16. Not even at the Natural History Museum where research is quite a substantial activity?

A. You have seen the plan. You may think that that did give it special prominence. I felt it dealt in an even-handed way with the various elements on which they wished to spend money over the next five years. As I say, in relation to that particular corporate plan,

because of its emphasis or change of direction we ensured that the museum itself had gone through the process of checking it with peer groups and that they were plugged into the government system. But we do not have scientific advice specifically accessible to us in the OAL for dealing with that sort of issue.

Chairman

17. Do you think the museums maintain in real terms the grant in aid, leaving aside the lumpiness of building costs?

A. I do not think I can go beyond saying that we have set out what the grant in aid is planned to be for all galleries and museums for the next three years, including 1991/92. They are set in the normal three-year settlement mode, as it were. As we have already discussed, in the last two years we have reviewed the three-year forward figures because of unexpected happenings in relation to inflation. I think the Minister has made clear in making his allocations this time round that if unforeseen circumstances occur he will want to consider reviewing them. They are not necessarily final figures if we get unexpected inflation. But that is not to say that if inflation exceeds by modest amounts the underlying figures assumed in the increases in grant in aid which have been signalled to them over the next three years it will necessarily be reopened. It has to be quite a significant going off course before the Minister will feel able to review it with his Treasury colleagues.

18. The expected underlying inflation rate is 4%, according to what you have set out?

A. Under the present settlement there is an increase of 4.2 per cent in year 2 over year 1 and subsequently in year 3 it is 2.8 per cent.

19. How much bigger would it have to be before there was some increase in funding?

A. I really cannot give you an indication of that sort. All I can say is that a 1 per cent or 2 per cent difference would look rather unlikely to cause people to think again.

Lord Flowers

20. There is a 3 per cent difference?

A. We are talking about a 4.2 per cent increase for 1992/93 over 1991/92. The Treasury's present forecast for that year is about 4½ per cent.

21. It was announced in the Budget that it was 7 per cent?

A. For 1992/93 over 1991/92?

22. According to the Chancellor, 1991/92 was 7 per cent?

A. But the 4.2 per cent relates to 1992/93 over 1991/92. We can let you have a note on the relationship between our figures and the Treasury forecast, if that would help.

Chairman

23. The document we have in front of us refers to a figure of 4 per cent per annum for 1990/91 to 1992/93, which seems to be somewhat at variance with what we have just been discussing. Of course, that is the Natural History Museum's corporate plan?

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MR CHARLES HENDERSON

[Continued]

[Chairman Cont]

A. That was before the figure was settled in the recent round.

24. Those figures will need upward revision?

A. All we can do is provide to the museum funds which we think reflect the situation that is going to exist, and no doubt they will reflect to us what they think the situation is going to be. We are due to get another corporate plan from them in the next five days.

Lord Flowers

25. Do they get an automatic increase if inflation turns out to be substantially more than you thought it would be?

A. No. The Government is not prepared to index-link funding to museums and galleries. However, in the Conservative manifesto issued prior to the last election they said they would maintain support for the arts.

Chairman

26. For that purpose "arts" includes "science"?

A. In this situation it must do so, yes.

27. I want to return to the central purpose of our inquiry. We have been set up to look at systematic biology, and the reason for the inquiry in part is its great importance worldwide and the very significant position which the Natural History Museum occupies in that sphere. You mentioned the fact that you would not take account of funds flowing in from government sources to the museum for research in making your own grant in aid. What would the reaction of the Office of Arts and Libraries be if the museum were to secure—indeed, perhaps it ought to do so in view of its international importance—funds from countries other than the United Kingdom?

A. I would be delighted. May I enter one slight technical caveat? If the money were secured from the European Community, there is an arrangement whereby anything that comes from them is deducted from what is available to OAL from domestic funds for funding museums, so my delight would be tempered by concern as to how to deal with that situation.

28. Or the extent to which you might get an exemption?

A. That might be one way of dealing with it.

Lord Taylor of Blackburn

29. Does that apply only to the European Community?

A. Yes.

Lord Butterworth

30. That is a deduction which takes places in the year following receipt of the grant?

A. There is a complication of that sort, too. The deduction reflects what has happened in the past year in terms of what is available in the forthcoming year.

31. Because the deduction would be from your grant, would you feel obliged to pass that on to the institution that had succeeded in the previous year in getting the grant?

A. I am not going to venture an opinion as to how I would want to deal with it. I would do my best to temper the particular rigours of that rule.

Baroness Nicol

32. I think I understood you to say that if the Natural History Museum makes a profit on something you do not take that into account when allocating funds to it for the following year. Would that apply even if they had a run-away commercial success and the figures were really significant? When you have those figures before you in making the allocation do you ignore them? How do you manage it?

A. As you have here in the corporate plan, most of the museums and galleries will forecast to us what they think they will be getting in the way of external funds. I must say I have not yet been confronted with a situation where a museum has forecast something of such a run-away nature that we have had to say, "Good heavens! You are doing so well that we will have to think about our whole strategy again". Frankly, I believe that is unthinkable. But if we knew they were having an extraordinary success we would obviously discuss with the museum how they would make best use of that success.

33. I understand that, but it would not affect your own level of funding?

A. In principle, it should not but taken to an absurd extreme, if they raised several tens of millions of pounds by some unexpected success I would be bound to pause, and you would probably want me to do so.

Lord Flowers

34. I am becoming exceedingly puzzled by this situation. The Natural History Museum itself and lots of scientists who have written to us about these problems have claimed that the taxonomy that the Natural History Museum does is extremely important and underlies biology itself and many other disciplines. Anything that depends on plants depends on the work of the Natural History Museum and work like that. If that is the case and if other subjects depend on taxonomy and the other subjects are funded by research councils—the Medical Research Council, Science and Engineering Research Council and so on—why is it you do not consult them about the very important part of their work you are underpinning in settling what their budget should be for their activities?

A. I have described what we do. We are relying on the expert management of the museum to carry out consultation and advise us in the light of that what it thinks it needs to be doing in all the fields it is working in. This is presented in the corporate plan which you have before you. We respond to that in the way I have described.

Chairman

35. The problem here is that in addition to the museum there are a lot of universities who have fingers in this particular pie and some are pursuing techniques and methods which are not available at the museum; some are essentially producing

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MR CHARLES HENDERSON

[Continued]

[Chairman Cont]

taxonomists in the future. One has the feeling that the whole pie itself, or the relevant parts of it, is not properly interdigitated. From what I can see of your funding, there is no way in which the funding which goes to the universities in terms of what they spend on systematic biology is related to what other bodies may spend, like Kew which is also funded by a government department. Our problem is to see how one maintains a proper balance and an appropriate effort in this field from the point of view of the United Kingdom?

A. I understand. I assume this is not a problem peculiar to taxonomy. There are areas of research going on in this country in all kinds of other fields which are fragmented where the arrangements for co-ordination and a full understanding of what is going on are equally difficult. This is not an unusual situation.

36. It is only unusual in that the Natural History Museum has a large activity itself in this particular area which is of vital importance because of its collections?

A. Indeed, but the Natural History Museum is in that sense a player on the scientific field in the way a lot of other ones are. I understand what you say. As far as we are concerned, the important thing is to make sure the experts are talking to each other and know what they are all doing.

Earl of Selborne

37. I understood Mr Henderson to say earlier that his department had consulted the Chief Scientific Adviser, Professor Stewart, on an overview of curation research. Could he elaborate further on what consultation took place with the Chief Scientific Adviser?

A. He met the museum scientific staff and the director. He has also facilitated their meeting with other scientific advisers in government departments and the ABRC. The conclusions emerging from that exercise were that he and his colleagues felt it was right for the museum to be concentrating on prioritising its efforts, and it was essential they should keep in touch with other bodies working in the same field within and without government. Indeed, he would be ready to facilitate further consultation if that was needed.

38. Do you feel it is needed, and have you any plans to progress that?

A. I do not think that at the moment we need to do more. The museum, if it had not got the message before, has now got the message about the need to bring into discussion all the interested players. When we receive the corporate plan we will certainly want to consult the Chief Scientific Adviser about it, which could lead to further discussion.

Lord Taylor of Blackburn

39. You said that when you received the corporate plan sometimes you would comment on it and sometimes you would not. In this case did you comment on the plan at all?

A. We had an extended meeting, if not two meetings, with the museum director and his staff. You can take it there was comment and questioning in that context. The formal response came in the form

of the Minister's letter, of which you have a copy, which made a number of points, but not directly bearing directly on the scientific content of the plan, as far as I can recall.

Lord Porter of Luddenham

40. Mr Henderson, presumably at some point the Office of Arts and Libraries has to make a very difficult choice as between allocating funds to, say, the National Gallery for the purchase of some picture or other and taxonomy?

A. It would not be quite like that.

41. Taxonomy is part of the activities of the Natural History Museum. What I am asking is how you make what must be a difficult choice. It is difficult enough to allocate funds to the sciences in the research councils. How on earth do you decide between such totally different animals?

A. We make a distinction between what the museums and galleries are planning to spend on buying pictures or, for that matter, specimens and what they spend on running costs, which would be from where the research expenditure is funded. Those are in different pots. Since 1985 the purchase grants of the museums have effectively been frozen on the ground that the resources we were able to secure for them were simply not enough to justify increasing purchase grants when there were very much more immediate needs in terms of running costs and buildings. That situation still obtains. In practice, it has been more painful as far as acquisitions are concerned than simply the effect of inflation, because prices of works of art in particular have gone roaring up relative to inflation.

42. Leaving aside acquisitions, if we take the decoration of the new wing of the National Gallery compared with spending on taxonomy, who makes the choice between the two?

A. The Minister makes the choice.

43. Between the Natural History Museum and National Gallery?

A. As an example, yes, and also as between buildings and running costs. He has available to him an overall sum of money for funding all the arts under his responsibilities. It is not just a question of deciding between individual museums; he has to decide between museums, the library, the Arts Council, BFI and so on. He has a wide range of decisions to take.

44. He makes that choice on advice?

A. Yes.

45. What is his main source of advice—the Office of Arts and Libraries?

A. Yes.

46. So, you really make the choice?

A. I do not accept that at all. I think ministers are extremely influential in final decisions. We tell the Minister what options are available to him in our view and he will decide where he wants to put his own emphasis, and we will advise him on what the implications of that decision may be.

47. Do you feel there is any difficulty in mixing something as different as taxonomic research with most of the other things for which you are

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MR CHARLES HENDERSON

[Continued

[Lord Porter of Luddenham Cont]

responsible? You feel that the Office of Arts and Libraries is the appropriate body to look after taxonomic research?

A. I would not say "yes" to the last question because it is not obvious why scientific research should be the responsibility of a department responsible for the arts. The difficulty with taxonomy is that it is heavily embedded in a museum; it is part and parcel of its work on its collections and the research it is engaged in. A decision has to be taken as to where in the spectrum of government departments the responsibility for funding that museum and all that it does should be. With effect from 1 April 1988, the decision was taken that it was more apt for the museum to be funded by the Office of Arts and Libraries than by Education.

48. I am aware of that. But I am asking whether in the light of what has happened since then and your experience you feel that that was the most appropriate thing to do?

A. I think it is awfully difficult to tell in practice what would have happened had it been left where it was, which is really what one is worrying about. One cannot speculate about Department of Education funding as compared with ours. All I can say is that my responsibilities in advising the Minister relate to a wide range of subjects, mostly in the arts field, in none of which am I an expert; I am not appointed to be an expert in those subjects. I would have to say that because taxonomy is quite different from all the other arts-related areas it does not fit particularly well with everything else we are doing. I and my staff are no less expert in taxonomy than we are on the question of fine art, rare books or whatever you like. We have to rely on the expertise of the people who have been appointed to run those organisations, whether it is taxonomy or fine arts.

Lord Butterworth

49. I would not wish you to think that what I am about to say I regard as the solution, but it might be helpful to us if you comment upon it. If you take the universities as a precedent, they have recently gone through an exercise which has been settled formally by the ABRC about dualfunding. They are now in the process of discussions which may lead to part of the recurrent grant being moved from the UGC and handed over to research councils so the research councils can become a more effective accounting body for the research being done in the universities. How would you react if that precedent were applied to you and it was suggested that part of your funding should be transferred to the appropriate research council so it could become wholly responsible for taxonomy?

A. I believe the problem centres on what I have said already, that taxonomic research is part and parcel of the museum and its collections. I would want to take advice from the museum on the point, as indeed your Sub-Committee will, but it may be it is quite difficult to distinguish between what is clearly taxonomic research and what is clearly the museum's other curatorial activities. Assuming the museum convinces the appropriate research council that it should continue to be funded for its taxonomy, there is still the risk that because there are two sources of funding each funder will look to the other to fund

more than the other thinks it ought to fund. There may be a gap in between. Dual responsibility of that sort is a recipe for under-funding.

Lord Flowers

50. To make another analogy, if I am an historian working for and paid for by a university I will use facilities provided by the university, but nevertheless I will do my research in the British Library by reading their books. Why should one not regard taxonomic research taking place in the Natural History Museum in the same light? They are using the collections and having intelligent conversations with the curators about the inadequacies or otherwise of the collections for their purposes, but they are essentially funded separately?

A. I do not think that answers the problem which exists. I am not adopting a strong position one way or the other on this. It is clearly an approach that could be considered, but I think the problem I have raised is one on which I would like to hear more expert opinion. I am not able to advise the Sub-Committee myself. No doubt you will want to ask the museums.

51. It seems to be an all-or-nothing approach, does it not? The Natural History Museum and all its works are to be regarded either as science or as OAL matters?

A. I do not think it is fair to say that because it comes under OAL's responsibility it is not science, which is the implication of the question. It is certainly right that it is more or less all or nothing in the sense it has been decided that either one department or another should be the prime funder, although they are getting money from external sources as well.

Chairman

52. I would like to return to the central point, which is where all this begins, namely, that the collections of the Natural History Museum are not just of national importance but of international importance. Therefore, the United Kingdom has a special responsibility for taking care of them and for proper curation and research on those collections because of their international importance. That is increasingly the case because of the problems facing countries now collectively in the form of global biodiversity and its use as a global change marker. Do you feel that when making your allocations to the Natural History Museum you have special regard for the fact that this is an international responsibility which the Government and country must accept; in other words, is there a protected amount of money which is a form of recognition of the importance of the collections?

A. Not explicitly hitherto. As I have said, we rely on management to advise us of what is needed. I would expect them to advise us if they felt that those responsibilities should be met and were not able to be met as a result of the funding they were getting from us.

53. If I may try to summarise our discussion, what you are saying is that the stance of the OAL is that it is responsive to the perceived wisdom of the trustees as they evaluate the situation and bring their views to you. You respond to that, taking into account the

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MR CHARLES HENDERSON

[Continued]

[Chairman Cont]

other pensioners on your vote. Is that a fair statement?

A. Yes. I would like to add one other dimension to it which has been a thread running through what I have said. As with all our museums, we do not just take the advice we get from the museums without satisfying ourselves insofar as we can that it has been arrived at in a rational fashion. We want to be satisfied that the systems for taking decisions in the museums and galleries are good ones. In this case, the system of consulting with peer groups is what we look for.

Lord Butterworth

54. I want to raise one question about Europe and the question of pay-back. Have you had any experience of this, or is it a theoretical fear?

A. It is real. It has not occurred in relation to the Natural History Museum or their research funding, as far as I know. But there have been museums under our responsibilities who have secured funding where we have had problems of this kind.

55. I ask the question, because a European committee of this House looked into that question. My recollection is that that committee was told by the Treasury that it drew a distinction between public and private funding, and the claw-back operated only in the private sector and universities for this purpose were classified as being part of the private sector. That was why they got into difficulties. If it was the public sector—for instance, if it was the huge new centre in Birmingham—the Treasury would take the European grant into account and greater funding for a particular department would be made available than would otherwise be possible because of European funding. The universities are in difficulty because they, like industry, are classified as being part of the private sector. The implication of what you are saying is that probably museums and libraries would be classified as part of the private sector?

A. I must say you are taking me into territory with which I am not one hundred per cent familiar. If I may, I would like to investigate it.

56. Could you let us have a note later? We have an interest which goes wider than what we are discussing this morning. If you have any experience of it it would be very useful to us to know.

A. I will certainly look into it. If I can have the reference to the other committee I would find it very helpful.

Lord Butterworth] You may find the evidence given by the Treasury quite interesting.

Lord Whaddon

57. To what do you attribute the concerns being expressed in some circles regarding taxonomic research? Since you seem satisfied you are responding to the informed concern of the curators, not the trustees, to what do you attribute that concern in areas outside the particular discipline? Is it just bloody-mindedness, or is there some real cause for concern?

A. It is certainly not bloody-mindedness. As I said at the beginning, if you are concentrating your resources on specific areas within a subject there will be people working outside those specific areas who will be concerned that the resources for their research will be more limited than they would otherwise be. It would be foolish not to expect there to be some concern being expressed. Our response to it is to ensure that that concern is registered and known by the museum, as is the opinion of other professionals, and that the museum is responsive and flexible in the light of the whole spectrum of opinion that it is receiving.

58. Are you aware of any changes in funding or organisation which have taken place in response to such pressure?

A. In relation to this story, no, because it is still too fresh. The announcement as to where they were proposing to go was made only last April, and discussions took place during the summer. It may well be that the new corporate plan I am about to receive will refer to that.

59. You remain sensitive to it?

A. Yes, and indeed we would expect the museum to show they were sensitive to it.

Chairman

60. Mr Henderson, on behalf of the Sub-Committee, thank you very much for coming. We look forward to receiving a note on the question of attribution as between the public and private sector.

A. It is not a subject on which I expected to provide a note, but I am happy to do so.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 16 April 1991

NATURAL ENVIRONMENT RESEARCH COUNCIL

Dr Eileen Buttle and Dr P B H Tinker

OVERSEAS DEVELOPMENT ADMINISTRATION

Mr A J Bennett, Dr J C Davies and Mr J Perfect

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TUESDAY 16 APRIL 1991

NATURAL ENVIRONMENT RESEARCH COUNCIL

Present:

Adrian, L.
Dainton, L. (Chairman)
Flowers, L.
Nicol, B.

Selborne, E.
Taylor of Blackburn, L.
Walton of Detchant, L.

Memorandum by the Natural Environment Research Council

EXECUTIVE SUMMARY

- (i) Systematics is a fundamental tool of biologists with a vital input both to pure and applied research. Its applications range from conservation of individual species through development of pollution indicators, treatment of disease to exploitation of living and non-living resources.
- (ii) Well curated reference collections are a basic resource for good systematic research. The UK holds many collections of international importance which need to be accessible for study by national and overseas visitors.
- (iii) Despite its core position in biology, systematics has acquired an unfashionable and dull image. It is largely ignored in school and undergraduate teaching. The amount of research on systematic biology overall also appears to have declined markedly in the last decade. Most of the taxonomic expertise is now vested in researchers in their 50s and effort is needed to enthuse, train and resource new workers. The considerable contribution of the amateur worker and retired professional should not be ignored.
- (iv) British systematists are embracing new methods and techniques, with molecular techniques proving particularly valuable in some areas. There is a continuing role for classical as well as new techniques but more needs to be done to build bridges between the two. There is also a need to develop and co-ordinate the production of computer databases.
- (v) Systematics is an international science and national policy for systematic biology research and selection of national priorities should be developed in the context of an international framework. An international register and network of expertise should be established, perhaps starting first at the European level. Broader international agreements might follow to focus primary research on certain groups at certain institutions in certain countries, with arrangements to exchange or provide services on payment as appropriate to researchers and other users in other countries.
- (vi) Industry should support some systematic research. Public funding is however likely to remain the main source of funding. The level of public support might be based on guaranteed provision of a certain minimum infrastructure to protect the important collections and their curation and go some way towards maintaining key centres of excellence for research based on these collections. Over and above this, support should be sought in full competitive mode.

INTRODUCTION

1. The term systematics is often used synonymously with taxonomy, but is sometimes interpreted more widely to include identification of organisms, their classification, nomenclature and evolutionary relationships. This response assumes the wider definition. The response draws upon the views of scientists in NERC research institutes and units and also on the views of individual NERC Council members with special interests in biological research.

2. Systematic biology research can be considered at a number of levels:

- direct “cutting edge” research on relationships between organisms or on the development of new techniques for studying such relationships.
- the practice of classifying organisms and re-working of existing classifications.
- provision of expert identification of organisms as a service to research teams and others.
- research which requires the employment of taxonomic skills.

Systematic biology is a fundamental biological science with important applications in the environmental, agricultural, industrial and medical fields. It therefore represents a true interface area between the Research Councils.

3. The Natural Environment Research Council (NERC) has no primary responsibility for basic research in systematic biology. It does, however, support such research in relation to the needs of environmental science in its own research institutes and units, through research grants and studentship support to the HEIs

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and to the Natural History Museum (NHM), and through a taxonomic publications grants scheme administered for NERC by the Linnean Society.

4. It is not possible to estimate the total level of NERC funding for systematic biology because in NERC institutes and units research on systematics is closely woven into the programmes which it supports; there is no separate accounting for such research. In terms of responsive mode funding to HEIs and the NHM however, NERC is currently committed to supporting research grants and studentships totalling in value £662k and £256k respectively. The current value of the taxonomic publications grants scheme is £5k per annum. There is also a NERC Special Topic in Biomolecular Palaeontology with £630k committed over 3 years.

5. Almost all the major NERC institutes include some systematic biology within their programmes and important reference facilities are housed at a number of sites for use by the wider national and international community. The British Geological Survey (BGS) houses one of two major UK collections of fossil material and the only one to be organised on a stratigraphic basis. The British Antarctic Survey (BAS) has recently established a Terrestrial and Freshwater Resource Centre which brings together living and dead specimen material as well as a range of databases covering biogeography, microclimate and biogeochemistry. Fundamental to this Resource Centre, which hosts visiting taxonomists and ecologists, is the herbarium (the largest in the world of Antarctic plants) and the Antarctic Plant Database. The Culture Collection of Algae and Protozoa is housed at the Institute of Freshwater Ecology (IFE) and Dunstaffnage Marine Laboratory (DML). The Institute of Oceanographic Sciences Deacon Laboratory (IOSDL) houses the Discovery Collections which are an internationally important collection of biological oceanographic material mostly from the Southern Ocean and the North Atlantic. In the course of its research NERC also accumulates and holds on record large quantities of data on species distributions. Although important to systematic biology in its broadest sense, this aspect is not considered further in this submission.

6. The Committee will be aware that there were two reviews of taxonomy in the 1970s. There was a NERC Working Party review of "The Role of Taxonomy in Ecological Research" in 1976, and an Advisory Board for the Research Councils (ABRC) review of "Taxonomy in Britain" which published its report in 1979. A summary of the conclusions and recommendations of the NERC report is attached at Annex 1. Many changes have occurred since these inquiries, especially the potential for application of modern molecular techniques to advance taxonomy, recent developments at the NHM, and increasing concern about biodiversity and the need for sound underpinning knowledge of species diversity. With these developments in mind NERC Council agreed last Autumn to support another review of national requirements. Proposed terms of reference for this review, which will be run by NERC but with the involvement of other Research Councils and relevant organisations, are attached at Annex 2. Membership is currently being discussed.

7. In putting forward this evidence NERC would in particular wish to emphasise the need to consider the UK contribution to systematics within an international context. References are made to this in response to issues (viii) and (x) below, and this is an area that the new Review Group (para 6) will be addressing. Without prejudice to the views of that Group, we believe there may well be scope for more selective development of taxonomic expertise in different countries, for establishing a network of centres of excellence and for developing international agreements for these centres to exchange or provide services on payment to researchers and other users in other countries. This might be organised initially on a European basis but ultimately extended worldwide. Such an arrangement would require a commitment by host countries to sustain their centres of expertise in particular areas at some minimum agreed level of infrastructure. Additional support, providing the superstructure, would then be sought and won on a service contract and/or competitive research grant basis.

ISSUE (i)—What is the utility of systematic biology research?

8. Systematics is as fundamental to biologists as are the laws of physics and chemistry to non-biologists. As a tool it has a vital input both to pure and applied biological research. An agreed and correct identification of organisms is, for example, essential to the proper documentation of experiments and observations, so that other scientists may independently check or develop the work, be that work in molecular biology, physiology or ecology. The contribution of systematics to an understanding of functional characteristics, variability, evolutionary and ecological relationships of species is fundamental; without this understanding much of biology loses its frame of reference.

9. Some examples which illustrate the wide application and intrinsic nature of systematics include:

- *Climate change:* Many sibling species (that is species that are genetically but not necessarily morphologically distinct) may have slightly different preferences for environmental conditions. The effects of temperature and other climate induced changes have to be studied on precisely defined species or stocks. Analysis of pollen and other material preserved in the fossil record provides evidence of past climatic change and its effects and a context against which to interpret current and future change.
- *Toxicology:* The physiology of species can be as unique as their morphology and the effects of pollutants can differ greatly from species to species.

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- *Fisheries Science*: It is now widely recognised that fisheries management has to be done on a multispecies basis because of interacting effects. The biological units (species or stocks) must be correctly identified and measured.
- *Conservation of Individual Species and Biodiversity*: The state and the status of species in a community are essential information for management of conservation and resource recovery. Gaps in knowledge are proving a major hurdle in drawing up an International Convention on Biodiversity.
- *Disease*: In many species of medical and agricultural importance, research has shown the existence of sibling species which may have different responses to drugs and pesticides. Effective treatment of pests and pathogenic organisms will depend on identification of the particular species or strain involved.
- *Biological Control*: Biological agents released to control insect pests and weeds must be accurately identified if potentially serious errors are to be avoided.
- *Hydrocarbon Exploration and Exploitation*: The accurate dating and correlation of rocks from their fossils and through this the provision of insights into biomineral formation, depends on sound identification and thorough knowledge of the fossil groups in question.
- *Biotechnology*: The correct identification of naturally occurring organisms with new and desirable properties is essential. In genetic modification, and when cloning plants as in new horticultural and forestry techniques, it is vital to define the organism being worked on including its strains and mutants.

10. It must be emphasised that good systematic research is not simply concerned with naming and describing things. It is an interactive science, making sense of the diversity of nature, enabling and playing a part in hypothesis testing in many areas of biology, and underpinning work where a clear identification of organisms and their relationships is needed.

ISSUE (ii)—Does the need to specify particular organisms in connection with e.g. intellectual property rights, regulatory provisions, etc. impinge upon your work?

11. All work using gene modification techniques is subject to regulations imposed by the Advisory Committee on Genetic Manipulation (ACGM). There is a requirement for all users of this technology to submit annual returns which specifically define the organisms used.

12. Any patent application involving an organism will also need to specify the organism in detail.

13. Regulations applied to the export of cultures require the organism to be named and pathogenic characters stated. Similarly regulations involving the import of material from abroad for experimental work in the UK requires specification of the species involved.

14. Even more important, however, is the basic scientific need to make absolutely certain that other researchers know exactly what is meant when a specific name is cited. The classic example of how easily confusion can be generated by poor systematics is the case of *Xenopus*—the South African clawed toad. This was used as a standard laboratory animal by physiologists who assumed that all “*Xenopus*” available through laboratory suppliers were the same. After many years it became evident that data emerging from different laboratories were highly inconsistent; a taxonomic investigation showed that seven different species and hybrids were being used.

ISSUE (iii)—Is the level of UK research appropriate. Is so, how does one determine an appropriate volume? How does it rate with competing biological and other disciplines?

15. Although we cannot quantify the level of UK research our perception is that, despite its core position in biology and Britain’s great strength in systematic biology in the past, the amount of research on systematic biology overall has declined markedly in the last decade. It is notable that this is increasingly remarked by those concerned with applications as well as by systematic biologists themselves. Much of the taxonomic expertise in the UK is now vested in researchers in their fifties. If there are problems now they will be greater in ten years’ time when many of these researchers will retire, unless an effort is made to interest and then train and resource new experts.

16. A major problem is that in its presentation this area of research has gradually acquired an unfashionable and dull image. Much of the work has the appearance of being tedious, “putting stamps in the album” rather than exciting “hypothesis-testing” science. As a consequence interest in the subject, its status, and the chances of receiving grant support are all lower than for more glamorous areas of research at the so-called “cutting edge” of science. Advances such as numerical taxonomy have not stemmed the loss of support. The introduction of “modern” systematics based on the use of biochemical and molecular methods may improve the perception of systematic research but it has to be recognised that although such methods are a great advance they are at present a complement to, rather than a replacement for, traditional methods of

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identifying organisms. For many years to come there will still be a need for classical taxonomy providing up to date keys to groups of organisms.

17. Despite its demonstrable utility and pervasiveness, one of the factors contributing to the poor image of systematic research and to its lack of success in grant funding may be the increasing difficulty faced by researchers in finding journals to publish taxonomic descriptions and other systematic studies. We are told that delays can be as long as 3-5 years. When careers can depend on publication rate and citation indices, some systematic biologists when judged solely on this basis stand little chance of appearing to perform well and being worthy of support.

18. In recognition of the need to encourage new interest in taxonomic research, NERC part-sponsored a North Atlantic Treaty Organisation (NATO) Advanced Study Institute (ASI) on "Molecular Techniques in Taxonomy" at the University of East Anglia in July 1990. The aim was to provide an opportunity for "traditional" taxonomists to learn about the new molecular techniques, and for molecular biologists to learn about the potential for application of their science to systematics and ecology. The programme involved 20 of the world experts as lecturers and some 70 postdoctoral researchers from many NATO countries attended. There is considerable demand for similar initiatives in the future. Since NATO does not repeat ASIs, the European Science Foundation (ESF) Euroconference Scheme might perhaps be an avenue worth exploring.

19. In considering the level of UK research the considerable contribution of the amateur worker and retired professional to taxonomy, particularly in popular groups such as the vascular plants, should not be overlooked. In some cases these "amateurs" are the only British authorities on a particular group. They commonly provide their own microscopes and materials. The influence of modern technology (e.g. scanning electron microscopy (SEM), molecular techniques) and the development of numerical and statistical techniques as tools in systematics research, make it more uncertain that this tradition can be maintained. The scope for providing extramural training courses on the use of some of these techniques and facilities for some of these high calibre "amateurs" might however be explored.

20. There is no clear answer to the question of how one determines an appropriate volume of level of funding for systematic biology but there is no good reason why whole organism science, including systematics, should be so much more poorly funded overall than the traditionally big-spending sciences. In para 42 we propose an infrastructure/superstructure approach to the problem, using international comparisons as one possible guide.

ISSUE (iv)—Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate, e.g. importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?

21. The albeit limited pool of professional taxonomic expertise in the UK is of a very high quality. However, the size of this pool is fast diminishing and the balance of effort altering through changes at the NHM, retirements from research institutions elsewhere and an almost total lack of new appointments.

22. It is unreasonable to expect unlimited funds to support systematic biology and some degree of concentration and selectivity has to be applied. Although traditionally expertise has been spread across groups, research is now being directed increasingly into priority areas identified for their economic or social importance. We would support this move but would argue the case for considering concentration and selectivity on an international and not solely a national basis (para 48).

23. In considering concentration and selection of priority areas the following points need to be borne in mind:

- There should be scope for world-class systematic biologists to practise their science as they see fit—"blue sky" or "responsive mode" would be good descriptions of this vital activity. Such activities would need to fulfil criteria of excellence, timeliness and pervasiveness but would not necessarily be targeted to a particular application.
- There are a number of pressing global environmental problems that require major systematic inputs—tropical plant diversity to name but one, given massive rates of rainforest clearance. The systematic base must be strong and broad enough on an international basis to sustain the science contribution to global problems.
- Where there are significant gaps in knowledge on particular taxonomic groups that are practically important, such as disease vectors, crop pests, pollution indicators etc, resources can be targeted at these problem groups. A broader base may, however, be needed to put these groups into context.
- There is a particular need for increasing training and research in microbial taxonomy. At present microbial biology suffers from major difficulties of extracting, identifying and quantifying bacteria and other micro-organisms in the natural environment.
- The development and application of new techniques, particularly the use of modern molecular biology techniques and introduction of computing is producing a whole new set of taxonomic procedures and insights. This is a particularly high priority area for support.

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24. The problem with too much concentration is that if new problems arise or new environments become the focus of attention, there may no longer be enough expertise left in certain areas to respond. For example, the discovery of the hydrothermal vent systems in the deep ocean unexpectedly revealed novel communities with life styles of considerable scientific interest and potential economic significance. The description of this fauna has taken an excessively long time because, world-wide, there was too little systematic expertise available to tackle the problem.

25. Prediction of precisely where attention should be focused to ensure science can respond effectively to new problems and new challenges is fraught with uncertainty. In an ideal resource-unlimited world, all groups would be worked on. This ideal can only be approached through international co-ordination.

ISSUE (v)—What is the extent of our need for reference collections including foreign material (type collections, living culture collections, etc.) as a base for systematic research? Is provision for their storage and curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?

26. Well-curated reference collections are a fundamental resource for good systematic research. They are vital for the validation of identifications, saving in research time, historical appreciation and future research. The UK has many collections of international standing. The compilation and curation of these collections and their supporting documentation and literature is an investment in the future, with a value often greater to the community at large than to the institution immediately responsible. The collections provide a focus for experts in systematic biology and need to be available for study by national and overseas visitors.

27. As already noted (para 5) NERC maintains some special collections within its institutes. Such collections are largely restricted to those where there is a clear ecological focus. With interest growing in the effects of environmental change, these collections are taking on an enhanced value and their effective curation, databasing and accessibility is important. One of the major collections housed by NERC, the Culture Collection of Algae and Protozoa at IFE and DML, was reviewed in 1990. This review emphasised the value of maintaining these living reference cultures for use not only within NERC but more broadly for research use by industry and HEIs and for teaching at all levels, including schools. Teaching packs have been developed with joint funding from Shell.

28. Collections held in HEIs and local museums often provide valuable reference sources. NERC has, on occasion, given support to HEI scientists to re-work collections of ecological important groups into a form appropriate for depositing with one of the major national institutions. The cataloguing of marine isopod and tanaid collections held at Nottingham University is a case in point.

29. The need for microbial collections may well increase with the advent of the release of genetically modified organisms and the associated need to identify possible gene transfer to other organisms. The UK already has several important collections which rank with those in the US, Germany and Japan. There are the National Type Collection at Colindale (primarily for medical pathogens), the National Collection of Industrial Bacteria at Aberdeen, the yeast collection at the AFRC Institute of Food Research at Norwich, and the Commonwealth Mycological Institute at Kew (primarily for fungi and now a commercial unit).

30. The UK has a special responsibility for collections which are important for historical and geographical reasons. British workers were active in the late 18th and early 19th centuries and established important type collections at that time. Collections from the countries of the former British Empire are particularly important, being unique and irreplaceable. Collections held at British institutions such as the NHM and Royal Botanic Gardens (RBGs) are exceptionally important in world terms.

ISSUE (vi)—What new methods are there and how will this affect future UK research? Is the availability of information technology to systematic research being adequately exploited? Is UK research taking cognizance of the full range of new developments in this field?

31. New methods of relevance to systematic biology are developing all the time. These include techniques such as scanning electron microscopy (SEM) and the conceptual and numerical techniques of cladistics and biometrics. These can be applied routinely to any systematic problem. Molecular techniques on the other hand, particularly those using DNA probe-based methods to determine the degree of relatedness at the DNA level, may require significant development for any particular group. Currently the most useful DNA probes are derived from ribosomal RNA genes which, because of their universal presence in organisms and their relatively low rate of sequence divergence, have widespread application across the entire living world. DNA sequencing of RNA genes and the associated computing for sequence comparison is a sophisticated extension of this method, which will require a good basis in computing.

32. British systematics are aware of these developments and are embracing them to the extent that resources and expertise allow. NERC is strongly encouraging the application of molecular techniques to ecological research across the board, and is supporting special initiatives in biomolecular palaeontology and molecular and genetic analysis of marine systems. There remains something of a gulf, however, between those using traditional and molecular methods. This must be bridged if full advantage is to be gained through the

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complementary application of these methods. The recent NATO ASI Programme (para 18) was one attempt to bridge this gap.

33. Since considerable investment of resources is needed to exploit molecular methods, they need to be targeted at those areas where they can bring greatest benefit. For example, traditional taxonomic techniques have proved of little use in identifying the systematic status of microbial populations involved in the oceanic food web. Molecular RNA and DNA techniques are proving revolutionary in identifying the diversity of species that comprise these assemblages and something also of their functional diversity.

34. There is a real need to establish applications for modern information technology in relation to systematic biology, with investment in computer databases and in the manpower needed to transfer data into machine readable form. Some limited developments are in hand in certain areas such as palaeontology, oceanic biology, and terrestrial biology, but there is currently no computerised database of all known UK species nor little co-ordination in the production of such databases as are being established. The Commonwealth Agricultural Bureau International Mycological Institute at Kew is perhaps further advanced than many. Both national and international databases have been set up and it is participating in a Microbial Information Network Europe (MINE) sponsored by the EC Biotechnology Action Programme.

ISSUE (vii)—Is the current “institutionalised” base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?

35. Systematic biology is practised in a large number of institutions such as the NHM, supported via the OAL, the RBGs at Kew and Edinburgh supported via MAFF and SOAFD respectively, in Research Council institutes and in individual university and polytechnic departments. It is assumed, however, that this question primarily addresses the NHM, and also perhaps the RBGs as the “institutionalised” base.

36. A centralised approach to the maintenance of collections and of taxonomic and systematic expertise is probably sensible on two counts. First, in principle, it provides for better continuity and a balanced assessment of the effort in different areas and priorities for attention. Second, it ensures that a critical mass of expertise can be maintained to help other research by providing services and back-up in identification etc, and to act as a focus for the introduction and development of modern technology. There must, however, be a close partnership between those providing a service in taxonomy and those concerned with its research application. In some cases it may be appropriate to attach experts to ecological research teams but their work will be considerably enhanced by the back-up provided by a healthy and scientifically vigorous systematic biology base.

37. In recent times the funding base for systematic biology has not been perceived to be secure, but the same could be said for most areas of scientific activity. When funding is in short supply there is a tendency for the less glamorous areas of science to suffer at the hands of the peer review system. If DES were responsible for NHM it would have to compete on a level playing field with all other science disciplines. Changing the funding agency will not necessarily improve the level of funding.

ISSUE (viii)—If research is to be continued, who pays?

- (i) Should the burdens of expense be shared with other countries, e.g. a UN programme? Can ESF help to rationalise activities?
- (ii) Within the UK, how much more should Government pay for and how best can budgets be protected?
- (iii) What role can industry play?

38. It is essential that basic systematic research should continue as an integral part of biological research. The problem inhibiting growth is clearly funding and trained manpower. As in other areas of research, it is unlikely that Government sources will ever provide all the financial support that researchers would desire. Additional funds need to be sought from other sources or better use made of existing resources through collaboration with other research programmes abroad.

39. Systematics is an international science. It is essential to agree on classifications, and systematics needs to be addressed in an international framework. As far as collaboration abroad is concerned, individual workers are usually aware of the existence of relevant research by workers in other countries by personal contact. What is really needed, however, both for systematic biologists and their “customers” is a Register and Network of expertise.

40. Although there have been some initiatives for particular groups, for example the Network sponsored by the EC Biotechnology Action Programme (para 34), we are not aware of many serious attempts within the broad field of systematic research where networks or research proposals have been initiated at the institutional level on an international basis. Such developments could not only make better use of existing finance but could act to avoid overlapping but independent investigations.

41. With regard to collaboration at a European level a training and awareness role has already been suggested for the ESF through their EuroConference scheme (para 18). On a more formal basis, the European

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Commission (EC), could perhaps help avert the shortage of specialist knowledge when viewed only on a national basis. For example, funding for and implementation, initially on a European basis, of the formal network of specialists proposed in para 39 would be regarded by many as a valuable contribution which should be initiated at the earliest opportunity. Internationally co-ordinated science on this basis would be more credible in the quest for additional funding from international bodies (EC, UN, World Bank, etc.) than bids from individuals. An international network would also help provide the framework against which UK priorities should be determined.

42. Like any science, given unlimited resources systematics could absorb considerably more funds. With some exceptions, the beneficiary of such research is usually society, rather than individual groups or companies. It seems difficult, therefore, to identify significant potential sources of support other than through public funding. The question of how much funding is more problematic. It could perhaps be based on consideration of infrastructure and superstructure with some earmarking of funding to underpin systematic research at a standard which does not fall below certain minimum agreed critical levels. What this standard might be is a matter for discussion and international comparison, but at the least it should protect the important collections and their curation, and go some way to maintaining key centres of excellence for systematic research. Support over and above this level, for specific research activities, should be sought through normal responsive mode machinery and contract research.

43. In some areas industry does recognise the need for good taxonomy and is supporting research. In micropalaeontology, for example, the oil industry has already made significant support available and will probably continue to do so. Some commercial companies support microbial taxonomy as do the water industries. However, in this area the contribution is small and unpredictable and largely revolves about the need to solve practical problems. The pharmaceutical and agro-food industries should also have an interest in systematic biology from the point of view of developing new products from natural or genetically modified organisms. Industry might be encouraged to contribute more to support specific research in institutions or groups and the use of the LINK scheme might be worth exploring. It seems unlikely, however, that industrial demands for taxonomy will ever be adequate to maintain an adequate core research effort based on properly curated collections.

ISSUE (ix)—Is teaching adequate?

44. Teaching is declining because systematics is an unfashionable subject. NERC experience with students is that few have even a basic modicum of knowledge about types of different animals and plants, and none have had any formal (or informal) tuition on taxonomy or systematics.

45. This lack of teaching pervades particularly at school and undergraduate levels. Thus, although there is a great public awareness of living organisms and ecological problems, biology courses give greater prominence to cellular biology and genetics, reducing other areas that were taught previously. The chief casualties appear to have been plant and animal morphology and systematics.

46. At postgraduate level, there are a number of Diploma and MSc courses which include some systematics, and a Diploma course at U C Cardiff on applied insect taxonomy and an MSc course at Reading on pure and applied plant and fungal taxonomy. We have no knowledge of the level of demand and destination of students trained on these courses however. What is important is to interest at least some students in continuing the subject as a career. This will only happen if the status of the subject is raised, its relevance made more apparent and basic support provided.

ISSUE (x)—What can we learn from abroad, especially the USA?

47. US taxonomists are no better than those in the UK. America has, however, recognised the need for better funding for taxonomy and may be ahead of the UK in its response. The only surviving US institution conducting systematic research to any great extent is the Smithsonian. Something could perhaps be learned from the level of support for curation and taxonomy there, and also from the US interest in assessing the needs and priorities for systematic research.

48. We would emphasise, however, that taxonomic specialists are located all over the world and that perhaps the time has come to look for a rationalisation of expertise and activity on a wider scale. Europe has a considerable number of systematic collections. Perhaps there should be international agreements to focus primary research on certain groups at certain institutions. This has happened so far by accident, with individual museums and botanic gardens for example taking on specific regional floras. A more structured agreement, in which particular countries undertook to provide for specific centres of excellence for organism groups, might be one option for the future.

49. The proposed NERC Review Group will be taking special account of developments elsewhere in the world and the extent to which changes in the UK might be aligned with action taken overseas.

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ANNEX 1

1976 NERC WORKING PARTY ON THE ROLE OF TAXONOMY IN ECOLOGY

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. SPECIFIC AREAS WHERE LACK OF TAXONOMIC EXPERTISE HAMPERS NERC'S RESEARCH

1.1 The primary value of taxonomy to NERC is as a basis for ecological research and our recommendations for research therefore usually apply to organisms thought ecologically important.

1.2 Of the two branches of taxonomy we are more concerned with identification, but fully recognise the basic importance of systematics.

1.3 The main needs relate to the ecologically important and under-researched groups. This is because both ecological research, and inventories for nature conservation purposes, have often been concerned mainly with the larger, better known organisms which are frequently less important in ecosystems than less well-known micro-organisms or invertebrates. We therefore recommend more research particularly in the high-priority groups.

1.4 Institutes funded from NERC, particularly the Culture Centre of Algae and Protozoa with its responsibility for developing a high-priority area, need to relate their taxonomic work to ecology.

1.5 Attention must also be paid to indicator species, to organisms in under-researched ecosystems, and to the subtler features of intraspecific taxonomy where they relate to ecological relationships.

1.6 Council should also examine the extent to which our conclusions apply to other topics, e.g. palaeontology.

2. SPECIAL ASSIGNMENTS

Early attention should be given to supporting taxonomic work in the neglected ecologically important groups.

3. PUBLICATIONS

3.1 More keys, monographs and handbooks are needed especially in certain areas.

3.2 NERC Institutes should be encouraged to:

- i Summarise and publish literature in important groups in which they have expertise.
- ii Examine, in view of the growing problem of publishing large taxonomic papers, the mechanism for publication in NERC journals if there is no such policy.

3.3 Council should recognise that to aid the production of appropriate taxonomic works it may be necessary to provide for art work and secretarial help and these should be regarded as legitimate claims on Research Grant Funds.

4. TAXONOMY METHODOLOGY

Encouragement should be given to the use of mathematical, chemical and computer techniques in the taxonomy of ecologically important groups.

5. RELATED RESEARCH NEEDED TO COMPLEMENT TAXONOMY

We recommend support for the following as being likely to benefit identification and/or taxonomic research:

- (i) Methodology for sampling and sorting.
- (ii) Elucidation of life histories of species thought ecologically important.
- (iii) Methods for establishing and maintaining collections and cultures.
- (iv) Study of intraspecific variation in species of ecological importance.
- (v) Preservation techniques.
- (vi) Microscopic techniques.

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6.1 NERC-funded institutes should be encouraged to develop collections of clear ecological interest and, more exceptionally, of more fundamental scientific interest.

6.2 Well-documented reference collections resulting from work funded by Council should be deposited in institutes or museums where a high standard of curation can be guaranteed.

7. TRAINING

7.1 NERC should encourage, if necessary providing some of the modest financial support required:

- (i) Short specialist courses at, eg NERC Institutes, Biological Records Centre, Field Studies Council, in the ecologically important groups.
- (ii) Apprenticeships and short attachments at, eg institutes and the BM(NH).
- (iii) Improved personal contacts.

7.2 Junior staff at institutes should be encouraged to benefit from 7.1.

7.3 NERC Research Studentships should be available to promising young taxonomists who, under appropriate supervision, could help to meet some of the priority needs.

7.4 NERC PhD students should arrange with HQ to deposit theses that contain taxonomically interesting conclusions.

8. SPECIALISTS

8.1 Council should recognise and capitalise on the taxonomic contributions made by NERC Institutes, amateurs, and scientific societies.

8.2 Amateurs and societies should continue to be helped through contracts, travel grants and the funding of ad hoc meetings.

8.3 The potential benefits of collaboration with taxonomists outside the UK should be exploited.

9. FUNDING

9.1 We consider the present level of funding of taxonomic work at NERC Institutes about right.

9.2 We consider that Research Grants and Training Awards on taxonomic topics receive too low a proportion of over-all funds for NERC university support, and the proportion should be increased should suitable applications be received.

10. SCRUTINY OF RESEARCH PROPOSALS

10.1 NERC should not support taxonomic research put forward in the guise of ecology and should give low priority to revisions of groups where ecologists can already unambiguously name most of what they encounter; to groups of low ecological relevance; and (less rigid) to groups recently worked.

10.2 Proposals for ecological research projects in institutes and in applications for research grants should be scrutinised for evidence of clear thinking about the degree of taxonomic precision needed to achieve their ecological objectives.

10.3 "Borderline" cases for support by NERC or other Research Councils should be examined jointly.

ANNEX 2

**NATURAL ENVIRONMENT RESEARCH COUNCIL
REVIEW GROUP: EVOLUTION AND BIODIVERSITY—THE NEW TAXONOMY**

Proposed Terms of Reference

- (i) To consider the needs of the biological sciences community for the identification of material;
- (ii) To examine the requirements for taxonomy in the UK, for maintaining a body of expertise, and for training, such that the discipline can be continued, and the needs of other sciences can be met;
- (iii) To assess the impact of modern molecular techniques upon the study of evolution and relatedness of organisms, and to determine how this can best be used to advance taxonomy;
- (iv) To consider the special problems and needs of microbial taxonomy in relation to the discipline as a whole;
- (v) To consider the requirements for the study of biodiversity, or the different numbers of species occupying particular niches, ecosystems or biomes, and to determine how taxonomy, both in its classical and its molecular modes, can contribute to this;

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[Continued

- (vi) To consider how potential developments in taxonomy could contribute to progress in other fields and help address contemporary issues;
- (vii) To compare the position in the UK to developments elsewhere in the world, and to suggest whether changes in the UK might be aligned with actions taken overseas; and
- (viii) To make recommendation on such changes as are required in resources, scientific organisation, or direction of research to ensure that the needs of biological sciences in these areas are met.

Examination of witnesses

DR EILEEN BUTTLE, Secretary to the Council and DR P B H TINKER, Director Terrestrial and Freshwater Sciences, Natural Environment Research Council, called in and examined.

Chairman

61. Dr Buttle and Dr Tinker, thank you very much for coming today and thank you also for the written evidence which was full of interesting information and ideas, at least it seemed from my point of view. I wonder if you would care to make an opening statement yourselves or whether, since you know some of our concerns from the questions which we sent you, there are other points which you would like to add which we have not raised but which you think are relevant.

(Dr Buttle) Thank you, my Lord Chairman. May I thank you for inviting us to speak to you this morning. I feel it would be helpful if I could make one or two opening remarks merely to set the scene. What I would like to do, if I may, is to distinguish between systematic biology as a scientific discipline in its own right and systematics as a service to the pursuit of research elsewhere. I think that is a helpful distinction. From our point of view we believe the responsibility for funding systematic biology solely for its intellectual challenge lies with those councils which support basic biology which are SERC and AFRC, whereas NERC would see itself supporting research proposals to carry out systematic biology in the context of environmental science. We do that by a responsive mode process with which I believe you are familiar, and there is no limit to the number of proposals which we will receive or fund through that process. It depends entirely on the quality of the proposal ...

62. There must be a limit on those you fund?

(Dr Buttle) There are limits on those we fund which are limits on the cash side rather than anything else. There is no discrimination against systematic biology with reference to environmental science in that context. With regard to the pursuit of systematics as a service, so to speak, to environmental science, we have not been able to find evidence that environmental science in general is being thwarted by a lack of expertise in systematics. But there are particular areas where there are problems such as microbial ecology where, to some extent, progress in systematics has been waiting for the development of molecular techniques. The feeling in NERC's community is that we have to be careful that there are critical masses of experts and that they are not eroded without our being aware of it, that is our worry. Indeed, we hope that the review we have established will address that issue for us. Some of our staff in the past in our institutes might well have carried out updating of keys and identification aids in the margin of their research. As we have come under funding pressure and had to cut back in our institutions and staffing, the time

available for them to carry out that work may well be reducing. I believe that scientists in general would look to those keys to help them. We are looking to the review that we have initiated to analyse the current position and its implications. We can then address the solutions. Thank you.

63. Dr Tinker, do you want to add anything to this?

(Dr Tinker) No, thank you, my Lord.

Chairman] That enables us to go straight into the questions and brings us back to ...

Lord Flowers

64. Could I ask for clarification of what Dr Buttle has said? I am a little bit confused. You talk about basic versus applied systematic biology, and I understood the point you were making. Would you regard the problem of biological diversity, or lack of it, as a basic problem or an environmental problem?

(Dr Tinker) It is really a question whether the lack of biological diversity arises from land use questions. These are really social questions and as such one must say the habitat is being removed. In that case we are not looking at a taxonomic question at all. If one is looking at a more stable situation one is asking the underlying question why are there as many species as there are in this habitat. I would regard that as a fundamental question.

Chairman

65. You would not regard it as a fundamental question to have the loss of a particular group of animals due to some destruction of their habitat as a subtraction from biological diversity, particularly if they are irreplaceable.

(Dr Tinker) It is a major problem, but I would not have thought their loss was a fundamental problem for fundamental science to solve where the driving force is social and economic.

66. What you are really saying is it is a political problem to be solved?

(Dr Tinker) In many cases it is a political problem which starts it up, but, it throws up many associated scientific problems; the importance of the species being lost, where they fit into the total flora and fauna, and so on.

67. I do not think we want to get too far side tracked at the beginning of this because it is a point made elsewhere: there are X million species thought to exist and a fraction which have been identified. I would like to go on to this main point which really goes to the first question. You have the list of questions I think in front of you?

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DR EILEEN BUTTLE AND DR P B H TINKER

[Continued

[Chairman *contd.*]*(Dr Buttle)* Yes, my Lord.

68. You say in paragraph 3 of your written evidence that NERC does not in fact accept prime responsibility for funding research and you restated that in essence again this morning it seems to me. We have a little problem here in the sense we also find from the SERC that that tends to dismiss systematic biological research as being of relatively minor importance as seen from its point of view. You said a moment ago it was SERC and AFRC which ought to carry the main responsibility for core funding and systematic biological research. Have I taken you correctly?

(Dr Buttle) You have taken our position correctly, my Lord, but I think I would change the emphasis. Our interpretation is that it is not minor, it is pervasive. We all have a part to play in systematic biology and I believe the view taken by the ABRC's report was that HEIs—our research councils—and NHM—the National History Museum—all contributed some 22 per cent to the cost of taxonomy. I think that is the interpretation you will find, not one of us having prime responsibility and having sole responsibility for it. There are many aspects to it and we each have a part to play. To clarify the point—hoping to help Lord Flowers in that—if we received a proposal, a research grant proposal, and I am speaking hypothetically here, which wished to address the fundamental vulnerability of the species to be able to face change, not specifying that change, then I suspect that would be passed over to SERC to fund, whereas if it were to look at a species relative to, or in the context of, a particular environmental change, local, regional or global, we would deal with it.

69. Is there a proper agreement between the research councils as to what is their territory, so to speak?

(Dr Buttle) We have a working agreement. Proposals received by our research council are looked at by the secretariats and decided upon, whether it is our's or is better in another research council, and there is discussion between the two research councils.

Lord Adrian

70. I was going to ask, because in previous investigations of this Committee we have come across what are called "grey areas", what lies between the research councils? I have sometimes wondered how effective are the mechanisms for deciding which council will deal with straddling inter-disciplinary kinds of research? Are you happy these mechanisms do work well and do not leave a number of things unsupported whereby, because of their nature, one council says: "It is not for us" and the other council says: "No, it is not for us either"?

(Dr Buttle) Naturally I could not claim perfection in this area but I am satisfied it works well enough. It is easy to make claims that there are problems in these areas between us but I believe when I have looked at it it is working well. I do not believe systematic biology is suffering from that problem.

71. I recall a difficulty in the past, more particularly between the Ministry of Agriculture and the

Department of Environment, not so much between the research councils, where there did seem to be a gap in the communication of environmental matters particularly and I wondered if you knew of any comparable kinds of difficulties?

(Dr Buttle) No, I know of no problem. The problem, as I perceive it, is if you are funding systematic biology research by the responsive mode mechanism, which the research councils are, then it is almost contrary to the principle of that to say you have prime responsibility for the funding of systematic biology in some proactive way, that you would then take action to do something about it. Responsive is what it says—responsive. The opportunity is there to be funded by that route and the research councils try as hard as they can to have as much money put into the responsive area.

Chairman

72. Research councils do not operate exclusively in the responsive mode, they are quite proactive in various fields, and there is no reason why they should not be proactive in this field if they feel they need to be. May I ask, in connection with your statement of satisfaction that you felt nothing was lost by this mechanism of being responsive, is there a post hoc annual look at what is covered in this field collectively by research councils which would enable you to make such a statement with such conviction?

(Dr Buttle) I knew it was dangerous to make such a statement with any conviction, my Lord.

73. A fair question.

(Dr Buttle) It is a fair question. Each research council publishes by different routes the research grants it funds and I do not believe we have post hoc analyses within the office of that funding. But why I could express any confidence in this is that those who suffer from the feeling that they might fall between the gaps between research councils are usually not shy in coming forward to make the point. My Council Chairman and I are very sensitive to such claims because we believe it our responsibility to ensure no-one suffers from those artificial boundaries in science.

Baroness Nicol

74. Can I take it a little further? In your written statement several times you refer to the subject as being considered "dull" or "unfashionable". If it was felt it was necessary to raise the profile of the subject and to sell it a bit better to up and coming scientists, funding apart, who would be the lead organisation? Who would set out to change the image, who would pull everything in and try to sell the subject without having to find the money for it?

(Dr Buttle) I think, if I may, there are two aspects to that question. Firstly, those engaged in systematic biology may themselves prefer to raise the profile of their subject. They could do that, indeed they could do that by a number of ways, in terms of coming forward to us, for example, with proposals that require special attention. When we take a more proactive role in terms of funding science we do that not for some view in the office but because we are consultative in our processes with our community

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[Continued]

[Baroness Nicol *contd.*]

and we are very sensitive to initiatives taken in that community. I ask Dr Tinker to say more about that. If ecologists, for example, felt that there was some lack in terms of systematic biology I am sure the systematists and ecologists could get together and take initiatives to come through our various consultative processes to produce a claim which deserves funding. Then it would have to face the competition within our processes. To some extent raising the profile of systematic biology is difficult because of the systematists themselves. Our processes are open gates to them until it gets to the point where we have to decide our priorities in terms of which programmes we will support.

75. If, as you say, they are all in their fifties and running out of steam—I think that has been suggested in several places—somebody at some stage is going to have to take an initiative to try and move things forward.

(*Dr Buttle*) Let me give you an example, if I may. We had a recent initiative where NERC scientists and the Natural History Museum scientists got together with some European colleagues in Belgium, Germany, Portugal and Eire and put forward a research proposal to the European Community MAST programme, the Marine Science and Technology Programme, and that proved to be successful. That was systematic research as to the variability of offshore benthic populations in the Atlantic and the prediction of change in those populations. The Community can get itself organised and put forward proposals in that way and we will respond.

Lord Adrian

76. How many successful proposals have been put forward in this way in recent years, either before or after the change of responsibility for the Natural History Museum? Perhaps you do not have that?

(*Dr Buttle*) I am sorry, my Lord, I cannot answer that.

Lord Walton of Detchant

77. Although it is many years since I served on the MRC I am fully aware of some of the demarcation problems between the research councils. Can I clear my mind on another issue of definition and demarcation as to where systematic biology and taxonomy ends and where applied research begins. There is a good deal on paper about the use of modern technology such as DNA, polymerase chain reactions in identification and classification of species. For instance, if you take the microbiological field where new sub-types of organisms and new mutations are emerging, would taxonomy and systematic biology extend to the identification of the antigenic differences between different strains and sub-types with a view to having this information made available to those looking for vaccines?

(*Dr Tinker*) It is a very complicated question. Everybody agrees, I think, that taxonomy amongst the microbes is particularly difficult. The habit of exchanging genetic material means it is difficult to define a species. Furthermore, in all organisms there is a certain amount of intra-species variation. This is

extreme in the microbes amongst the groups which have been defined by standard taxonomic means. I have worked on the fungi, and we had trouble trying to define our organisms in a straightforward taxonomic way. It seems to me your question can only be answered by a lot more research. I doubt myself whether the standard taxonomic approaches are really suitable for the microbes as a whole. They are a major problem which has only really been touched on.

78. My reason for asking this question is because of the recruitment problem in that there are some people in biology who regard the old fashioned taxonomic approach as being stamp collecting, whereas for those who believe in the application of new microbiological and molecular biological techniques for the identification of species, they might find that intellectually much more exciting?

(*Dr Tinker*) If I could continue ...

Chairman

79. Could I add a point which you might wish to consider, I do not understand biology at all, I was a physical scientist, I could now be described as lapsed but seen from my external point of view the questions of what you might call molecular technique, to which Lord Walton has been referring, are useless unless there is some other form of identifying material on which you are working. Both are essential, neither is any good without the other. Is this the wrong impression? Perhaps you could include that.

(*Dr Tinker*) I would certainly agree that is true at the moment. I have seen statements from scientists who say the standard morphological methods describe biological taxonomy and the molecular methods describe relatedness. My own feeling is that as the molecular methods become more and more developed, eventually we will rely on them more and more. Recently there have been suggestions to move from the five kingdom classification to the three kingdom classification, based on molecular grounds. At the moment what you say is basically true. We must use all the mechanisms we have available. I suspect myself we will depend more and more on molecular methods as time goes on.

(*Dr Buttle*) I think if I may reinforce the point you are making, at the moment the advantage lies in bringing these two groups of people together and indeed that is why we supported the NATO workshop. I think the subject is changing and I think by bringing the two groups together we might spawn more interest, I take that point entirely. We are sensitive to that and will do what we can. I believe molecular techniques may well improve taxonomy and it will enable us to look at the morphology in a way we have not been able to do before because the morphology has been clouded by natural selection as well as taxonomy.

Earl of Selborne

80. To pursue the relative importance of traditional or molecular methods of systematics, you give an interesting example in your paper about the need for systematic expertise in oceanography around the hydrothermal vents. Here is an area you

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[Continued]

[Earl of Selborne *contd.*]

have identified where there could well be flora or fauna of potential economic significance where the basic taxonomic expertise was not available. I wonder, going back to the need to retain a pool of what one might call basic good traditional taxonomy, whether the NERC sees a proactive role in areas such as that, clearly an area where you would have a great deal of interest in that specific example.

(*Dr Buttle*) Indeed we do, in the sense that the hydrothermal vent example revealed that those who could address the taxonomy in that area were principally but not exclusively US scientists. That is why we are suggesting we ought to look in the international context rather than simply the national context. If there are critical masses of expertise elsewhere in the world then we should play a part perhaps in supporting that rather than recreating a new group in our own country.

81. I wonder if I could pursue this a bit further: if you decided that this particular area was something which was mainstream interest in the NERC, and maybe you have not so decided, to what extent do you feel a responsibility for developing a degree of taxonomic interest in this area in this country rather than relying elsewhere?

(*Dr Buttle*) I think we do not yet know where the centres of expertise are precisely. We know what we have in this country and from what we see we have more than our fair share, so to speak, in the sense this country has a long tradition of housing collections and acting as centres of excellence in this scientific discipline already. Even though we are taking the lead in a new review of national requirements, we would hope that all those who have an interest in systematic biology would share with us in this review and find out what we should do in relation to the international scene, to be sure that that infrastructure of expertise is there internationally. This is an overhead on almost all biological research.

Chairman

82. Given what one might call a legacy of the Empire which has led to these collections and therefore your interest in this field and given your interesting suggestions which related to one of the questions we put to you about the possibility of international funding on this, this does mean, does it not, at some stage if we are to look for funds internationally then somebody has to look at the whole of this field of research in this country to see what level of investment our's should be. Who is to do that? You say you do not have a major role here but SERC is reluctant to come forward, AFRC would accept responsibility I am sure. Where would it lie? Would it lie with AFRC? Would you think that was a reasonable question to put?

(*Dr Buttle*) Please do not misunderstand us. We are not saying there is not a need for this to be looked at across the board and that is indeed why we have set up this review. I do not think it needs one institution to take responsibility of the funding for us to resolve the issue. I think with international conventions on biodiversity we may have an opportunity that is going to open for us to have this discussed internationally. I am speculating now, but there may be a window of opportunity in the international scene

whereby we could bring our national findings to that forum. How that is done, incidentally, is yet to be decided.

83. You regard it as very desirable that it should be done?

(*Dr Buttle*) Certainly we should look to see what the issues are and where problems, if they exist, lie.

84. Could I perhaps bring you back to this question with which we began. We asked whether any important areas of biological research are being held back and you said you were not in a position to look at the whole field, but I notice at one point in your written evidence you state that an obstacle to the formation of the International Convention on Biodiversity was, in fact, lack of information. Would you care to expand on that? It was in paragraph nine, I think, of your written evidence. What is the international convention which is referred to? I do not think any of us have heard of it.

(*Dr Tinker*) If I may answer, my Lord. There is going to be a conference in Rio de Janeiro in 1992.

85. A conference?

(*Dr Tinker*) In Rio de Janeiro in 1992 under the auspices of the United Nations and we understand discussions on a Biodiversity Convention may be brought up there. At the moment there is no such convention that I am aware of.

86. So this will require from this country...It is under the auspices of what, the UN?

(*Dr Tinker*) Yes.

87. That will require some department to take the lead and to co-ordinate the pattern of work which we have here and the views, will they not?

(*Dr Tinker*) Yes.

88. Has that process begun?

(*Dr Tinker*) I understand the Department of the Environment will be the lead department.

(*Dr Buttle*) This is a UNEP Programme, it will be the Department of the Environment taking, from the Government point of view, the lead on that.

89. Irrespective of what we might say there is another pressure, if you like, which is requiring us to look at the whole of our work in this context.

(*Dr Buttle*) There is the international concern about biodiversity, which we believe is a concept rather than a topic. That concern, I think, will bring this issue of systematic biology into focus and I suggest it may come in this international forum.

Lord Walton of Detchant

90. Following that point up, is there a possibility that at that international meeting a start might be made by trying to establish some kind of international agreement to bring into being an internationally agreed database on taxonomy, something along the lines, but different lines, of the human genome project which has now got a great deal of international support?

(*Dr Buttle*) What I am in fact suggesting is that international meeting might be a window of opportunity for these sorts of areas to be addressed, no more than that, but it may or may not move in

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[Continued]

[Lord Walton of Detchant *contd.*]

that direction. We have identified the potential opportunity.

Lord Flowers

91. I am worried again about almost the same point. You said on this conference that the Department of the Environment would lead for this country. If what is being talked about is a basic scientific problem, diversity of species, which it really is, is it not, should it not be the Department of Education and Science looking after it rather than the DoE which is only interested in the application of such bits of biological diversity as are of interest to them?

(*Dr Buttle*) It is not proper for me to comment on which Government department should take the lead on which issue, but I understand the lead responsibility for matters in UNEP is with the Department of the Environment. If, as we are suggesting, there may indeed be a very important scientific input to those discussions, then the Department of Education and Science would indeed brief the Department of the Environment to take those issues and may well accompany them in that. There are mechanisms whereby the views of the Department of Education and Science could be fed into the DoE, it is simply the DoE would be the lead department but not exclusively.

92. I understand that but can I press you a little? Are you entirely satisfied that the arrangements between the Department of Education and Science, and through them the research councils and the Department of Education, will be adequate to deal with the problem I am concerned about?

(*Dr Buttle*) I am in no position to answer that in the sense it has to be tested. We, first of all, have to decide whether there is an issue we wish to take to that international forum and to some extent we rely on our review, and other reviews that are being carried out, to bring into focus the problems and possible solutions. If those solutions are international in nature, all I can say is the routes and mechanisms are there for that to work and the research councils will do what they can to ensure that the mechanism works.

93. My only comment is whenever there is a problem that contains the word "environment" it seems to go automatically to the Department of the Environment as the representative as far as Government is concerned but that is not necessarily the correct scientific thing to do.

(*Dr Buttle*) If I may make a comment in reply, my Lord. That has been the case but the evidence I have recently is of greater interaction. We have been, as a research council, involved for example with the Department of the Environment in EC matters and they have taken us very much along with them on that.

94. That is encouraging.

(*Dr Buttle*) That is encouraging.

(*Dr Tinker*) It may be worth adding there will be a preparatory meeting of scientists in November of this year for the UNEP meeting under the auspices of ICSU.

Chairman

95. We would like ideally to get a handle on the amount of money spent in this sphere from these diverse sources. In looking through your statement I gained the impression the kind of funds you applied to the question of systematic biological research of both categories, the applied and the other, is already just under £1 million a year, is that correct at the moment?

(*Dr Buttle*) We have looked at it since we wrote in our evidence to try to firm up that sum. You are certainly right, we believe it is in excess of £1 million, just a little over £1 million.

96. Do you have any plans from the Council point of view, or after discussions with other bodies, wanting to increase all that and if so to what extent? I could not find the figures in your Corporate Plan which broke it down into this detail.

(*Dr Tinker*) If I can answer one point: it is very difficult to disentangle this work. I made enquiries of the institutes for which I am responsible, and whereas only two people would regard themselves as taxonomists, 48 of them undertake taxonomic work as part of their normal operations. In these institutions taxonomy and ecology are so intermingled all along the process that costings would be difficult. Taxonomy is alive and well in many places but it may not be going under that precise label.

97. It appears from what you said that some of the taxonomists themselves are at the point of death, 50 plus. Looking around this table --

(*Dr Tinker*) I think maybe they have some years still to go! I think this is a slightly different problem. There are a large number of people who are doing taxonomy, which may well involve publications on taxonomic affairs, but as part of their other objectives. What they do badly need is a focus somewhere, an active mass of people dedicated to taxonomy, and it is this active mass, wherever it may be, which is the problem we were looking at in relation to that comment.

98. Would you care to comment where that should be? Should it be in higher education or the Natural History Museum or Kew, or wherever?

(*Dr Buttle*) We are trying not to pre-empt the review, but in previous reviews it was felt there was a balance to be struck between those who felt it should be separated in, for example, the Natural History Museum's groups of experts, and others who held the view it was better to have that expertise diffuse in the research community alongside those doing the research. I am satisfied our processes will support the latter, where we try to encourage ecologists, marine, fresh water, and terrestrial to recognise systematists have a part to play in bringing that element into their proposals. That is why it is difficult for us to disentangle it in terms of costings. In terms of supporting centres of expertise, I think we have to capitalise on where that expertise already lies rather than recreate it. For example, the Natural History Museum where one finds many of the collections and experts in modern flora and fauna.

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[Continued

Lord Adrian

99. Can I go back a bit and ask you about the teaching at a much more elementary level of systematics. You say under 44 in your evidence: "NERC experience with students is that few have even a basic modicum of knowledge about types of different animals and plants ..." I am well aware of this as the problem and I happen to have been enormously keen on just that sort of diversity of nature and classification at a very elementary level when I was at school. I realise it is not your specific responsibility to correct what is going on in schools but are you seriously worried that this is going to lead to a major problem in systematics of the kind you are interested in, applied systematics or indeed basic systematics in the near future, or are you aware of initiatives which will correct what seems to me to be a degree of anxiety on your part in your evidence?

(*Dr Buttle*) If I may I will answer and ask Dr Tinker if he wants to add anything to it. I think it is our worry, if I can express it in this way, that because that teaching is not taking place—and this is anecdotal evidence which we have, we have nothing tangible—because it is not taking place younger scientists coming through the system are not aware, in the same way they might have been, of the role of systematics and the importance of systematics in defining their experimental science. In the same way we have to in papers describe carefully the chemicals and sources of chemicals used, so we need to describe animals and plants. Because teaching is not taking place we are nervous that younger scientists may not be aware of and this may be taking it as read that somebody else will supply the knowledge to them for free or by keys. Certainly the scientists coming through are capable as ever to pick up taxonomy skills that they require for their research. I have no doubt about their ability in that way but they rely to some extent on turning to keys or to those who have expertise to help them if they get into difficulties. I think that is where the concern lies that there is no teaching. The profile of systematic biology is not being made at that level to be carried through.

(*Dr Tinker*) I would like to widen the concern to whole organism biology in total. We have been going through a biological revolution in which attention has been diverted to cellular and sub-cellular mechanisms. When universities appoint new staff, they often appoint people in these areas. It may be that the uniformity of life has been over-emphasised as against its diversity. I would hope that gradually the pendulum will swing back again.

Chairman

100. You say in your corporate plan there is an urgent need to reinvigorate the study of taxonomy. You are speaking of some serious concern which we share.

(*Dr Buttle*) Yes.

Lord Adrian

101. Are you happy to rely on the pendulum or do you think it ought to be given a push? I appreciate it is not your business to give it a push.

(*Dr Buttle*) We will give it a push where it is presented to us to push, if you follow me, and where we see problems.

(*Dr Tinker*) I think some of the problems which we have pointed to and which are very real, do show signs of changing. Back in the middle 1970s there was no doubt taxonomy was seen as a dull discipline. The new methods and new ideas coming forward, partly molecular, seemed to herald an upsurge in systematics research, and that is something within the confines of the Councils' remit that we can help. If I am right in believing that there is a change, that there is movement now, then we will do our best to encourage that.

102. If I may speak personally: I have an anxiety that although I understand that perfectly well and it provides a very exciting prospect, the background of what used to be taught in school on a sort of assumption on biological diversity is no longer there and that in a sense the framework within which the new molecular methods are interesting and are made interesting is in danger of no longer existing?

(*Dr Buttle*) You asked us if we were to take initiatives. What I would like to emphasise is that in the side of our Council where we are more proactive and concerned with environmental change and the processes of change, we support multi-disciplinary teams. Our initiatives have the scope for encouraging systematists to participate in the same way as we encourage the chemists and mathematicians and biologists and physicists to participate in focusing on issues of environmental concern and environmental relevance. So we are encouraging systematists to play a part and that is, if you like, the strength of the Research Council in the environment in that it can pull together multi-disciplinary groups. We hope we can encourage that further.

Chairman

103. Could I just go on a little bit further to the economic section of all of this work. You are responsible for geology and you have the BGS within your remit. Palaeontological research is of considerable economic importance?

(*Dr Buttle*) Yes, indeed.

104. Would you like to tell us how you regard that?

(*Dr Buttle*) First of all this is where you will be pleased to know we take full responsibility for funding of palaeontology because no other council has responsibility for geology in the way we do. We have valuable palaeontological collections at the BGS and of course, as I have said, our concern with global change and change in the future prompts us to look backwards as well. Palaeontological change is of direct relevance to our interest. We have taken initiatives in encouraging particular topics via molecular approaches to palaeontological issues. Within the training that we support, I understand that we have five CASE studentships in what we might call taxonomy if we can use that word, four are in the palaeontological area. We are pursuing linkages with industry in this area because undoubtedly the hydrocarbon industry will be interested and we will take every opportunity to persuade them to contribute funding where they can.

105. Could I pursue that a moment or two more, that goes wider than just economic geology, it goes to medicine as well.

(*Dr Buttle*) Yes.

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[Continued]

[Chairman *contd.*]

106. Are you satisfied industry is in fact in partnership with you or otherwise contributing towards the cost of producing what it ultimately draws upon, namely the knowledge and ideas on the hoof, if you like, of people? Is there a close enough link?

(*Dr Buttle*) I could never be satisfied in this area. I think we could always make progress and better connections between industry and the science base. It is particularly difficult to make those cases at the moment when we are in a recession and industry already has enough claims on its resources. We have an extremely good working relationship with the petroleum industry and many initiatives between us in that area. I am satisfied every opportunity that exists for us to capitalise on industry's support has been taken.

107. If we were to ask you for details of links, would you be able to supply them to us?

(*Dr Buttle*) We will certainly do our best to do so, yes.

Lord Flowers

108. In your very helpful evidence to us you have an annex which summarises the 1976 Working Party on the role of taxonomy and ecology and you list there, or they list there, six specific areas and one of them is that lack of taxonomic expertise hampers your research. What have you done to put that right since 1976?

(*Dr Buttle*) I think there is some ground for misunderstanding in this annex, on the conclusions and recommendations. The six high priority areas identified by the Working Party were virus, bacteria, algae, protozoa, fungi and deepsea benthos. Those are the six areas where in 1976 we identified a particular need. We have, of course, been talking about the problems with microbial taxonomy and I believe we have addressed the algae and protozoa, where we can, with our CCAP which is the Culture Collection of Algae and Protozoa, where we moved the collections of freshwater algae and protozoa to our Institute in Windermere close by the scientists who are carrying out research in that area, and the marine algae to our Institute at Dunstaffnage in Oban in Scotland. In terms of deepsea benthos we think the hydrothermal vent is a good example, almost an announcement of opportunity to taxonomists if you like, where the United States I believe sounded out the rest of the world to address this area. We held a NATO workshop to bring classical and molecular taxonomy together. We also put forward, albeit I recognise a small amount of money, money to assist in the production of taxonomic publications and keys. Dr Tinker can elaborate on that if you wish...

109. That does not quite coincide with what I thought the annex said, but never mind. In annex one of your paper you have a list, also of six things, of related research which complements taxonomy. May I ask some questions in relation to that. What have you done about those?

(*Dr Tinker*) Certainly on the first one, indicator species, it is pertinent to mention our RIVPACS system. This is using invertebrates in streams as an

indicator of water quality in general. This is a precise situation where taxonomy has been brought to bear to produce a whole suite of indicator species. This is a well-established system which is being taken up quite strongly by the water authorities.

(*Dr Buttle*) If you are referring to the little sixes in paragraph five, where the methodology for sampling and sorting...

110. Yes.

(*Dr Buttle*) This is where we have not, so far as I am aware, taken a Council initiative to address each of these issues individually but we have referred to them in terms of what we have done on, for example, the Culture Collection of Algae and Protozoa where we are encouraging research to be carried out there on the preservation techniques and benefits of freeze dry protection as opposed to maintaining cultures without cryo-protection.

111. Would you say as a result of that 1976 report there was a great flurry of activity to provide the missing pieces?

(*Dr Buttle*) I do not think I could describe it as a flurry of activity, my Lord, no, but in the context of that 1976 Report where we have in our normal course of business addressed taxonomic issues we have referred to this and made those initiatives in that context.

Lord Flowers] Thank you.

Lord Walton of Detchant

112. Could I ask whether, to come back to the industrial issue and industrial connections, whether you have had any opportunity of discussing these matters or similar matters with the pharmaceutical industry? You mentioned the petroleum industry but I was having conversations with representatives of the Association of British Pharmaceutical Institute, the ABPI, and they mentioned that: "Many medicines are synthesized in whole or in part by microorganisms, fungi or yeast; knowledge of systematic biology facilitates description and manipulation to improve yields, development of new reactions and allows new awareness of thought in this area." They then went on to say: "... actions of new potential medicinal substances are influenced in many different ways including metabolic conversions. The availability of DNA technology to characterise at the genome level adds a new beneficial dimension to systematic biology and this advance in knowledge is in its infancy." I wondered whether this was a possible source of additional support and funding for work in this field?

(*Dr Tinker*) I can only answer in generalities because I have no specific examples. It is certainly true in general but I think perhaps the number of useful substances which will be obtained in this way might be overstated. On the other hand, as we get more and more power to move genes from one organism to another at the gene level, as opposed to new products from plants or alternative crops, I think this will be a great source of variation for insertion in other plants.

113. My purpose really was to say this may be another source of funding because the

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[Continued]

[Lord Walton of Detchant *contd.*]

pharmaceutical industry is one of our biggest overseas earners.

(*Dr Tinker*) The pharmaceutical industry is well aware of this but at the moment they make their own judgements about where to find new products.

Chairman

114. The burden of your written evidence was that we did take, as you said at the beginning this morning, special responsibility and also special opportunities because of the collections we have here and the historical tradition. This does bring us, I think, back to the point as to whether, in fact, we should be slightly more generous in this country in the allocation of resources we give to systematic biology and all its different manifestations, pure and applied. But it also raises a question which, in a sense, is where public concern over this issue began, namely with the financial state of the Natural History Museum and the outcry there was about certain changes there. What we are finding it difficult to get a handle on, and I put the question to you, is one would accept the Natural History Museum, indeed you said so, is a critically important institution and it does appear that you yourselves are supporting the research there. We have no idea what is the level of that support, how it is affected over time and what are the principles behind it, whether you do it in your responsive mode and are judging it by the standards you apply to anybody else. Could you comment on all that, please?

(*Dr Buttle*) Yes, my Lord. First of all, may I suggest to you the model of the university might be relevant here in the sense that we see the Natural History Museum now gaining its funds by the dual support process. It gains its funds from the Office of Arts & Libraries to run a museum with curatorial processes, benefitting from its connections with other museums in how to do that in a commercial way, I imagine; the OAL also provides financial support for the salaries of staff, to do research for the museum in a similar way to UFC support to universities for research teaching. Then the Museum, of course, is free to apply to Research Councils for grants in the same way that universities are free to apply. That is how we are reading the Natural History Museum as it is currently established. We have I believe at the moment five research grants with the Natural History Museum, one is in the palaeontological area and the other four are across the terrestrial aquatic area. We have five case studentships with them and one fellowship. That is the current state of play. I am sorry but I cannot give you the previous state of play because we find that difficult to determine in the short term.

Lord Flowers: When we saw the OAL the other day they showed no understanding whatever that I could see of the principle of dual funding that you have so accurately described.

Chairman

115. They did not understand the importance of you cannot make bids unless you have a well-founded laboratory.

(*Dr Buttle*) Yes.

Lord Adrian: Could I ask whether there is any understanding, either present or future, in the matter of overheads? That is now quite a keen issue between the Research Councils and the UFC. I wondered if there was any equivalent recognition of these problems?

Lord Walton of Detchant

116. Not on a standard scale.

(*Dr Buttle*) Well, I think, my Lord, it is not for me to comment really. I think the Natural History Museum might use the model, I suggest, for dual funding in universities to take to OAL.

Lord Flowers

117. It is vital that both sides of the dual funding system understand what the system is.

(*Dr Buttle*) Exactly, I agree entirely.

Chairman

118. I think we have asked you a great number of questions, I wonder if we might trouble you to give us figures for what you spent in the Natural History Museum in past years? This is presumably an ascertainable series of facts?

(*Dr Buttle*) Yes, it is, for our current funding.

119. When did you start?

(*Dr Buttle*) 1987 my Lord.

120. We have put a lot of questions to you. Are there any points we have failed to cover which you would like to bring to our attention?

(*Dr Buttle*) I would like to make the following point which refers to the international dimension: I share your concern that while at the moment with the current interest and concern about systematic biology we may be able to address the issue and put in some solution, the difficulty nationally is to maintain that commitment over time and that is where international agreements can sometimes be of help.

121. Be of help?

(*Dr Buttle*) Yes.

122. On the other hand that represents commitment which withdraws money by definition from other activities so it is not without its problems?

(*Dr Buttle*) Indeed it does and we have many scars from making international commitments so we have to do it very carefully. We have to be sure we do need such a commitment to achieve our objectives.

123. Yes. Is there anything you would like to add Dr Tinker?

(*Dr Tinker*) No, thank you.

Chairman: May I thank you very warmly for coming to give your evidence this morning.

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[Continued

Supplementary letter from the Secretary of NERC

Further to our presentation of oral evidence to the Committee on Tuesday 16 April, I am now writing in response to the Committee request for further information on NERC responsive mode support to the Natural History Museum (NHM) since its transfer to the Office of Arts and Libraries (OAL) in 1987.

Prior to that date the NHM received such support only through the NERC research studentship scheme, as the non-academic partner in NERC Co-operative Awards for the Science of the Environment (CASE), and through support of Fellowships. With its transfer to the OAL, the NHM also became eligible to apply for research grant support.

Since 1987 eleven standard research grant applications and two small research grant applications (to a total value of £771k) have been received from the NHM. These applications were peer reviewed in exactly the same way as applications in these categories from HEIs. Four standard research grants and one small grant have been awarded (total value £409.5k). One of these awards was made in 1989, the remaining four in 1991.

Also since 1987 CASE studentships (with the NHM as a collaborating body) and Fellowships have been awarded as follows:

	1987	1988	1989	1990	1991
CASE studentships	1	5	1	—	2
Fellowships	—	—	—	1	—

When taking our oral evidence the Committee enquired about NERC's total funding for systematic biological research. The figure of £1 million a year quoted in our evidence represents only those easily identifiable elements: research grants, studentships and fellowships to the higher education institutions and the NHM (including the NERC Special Topic on Biomolecular Palaeontology); direct costs of the main collections held at NERC institutes; and our support for taxonomic publications. It does not include systematic biology research carried out in our research institutes, units and centres as an integral part of other research programmes. It is impossible to separate out and cost such research, but it can be reckoned that this support would bring the total level of NERC support to significantly in excess of £1 million a year.

Yours sincerely

Eileen Buttle

OVERSEAS DEVELOPMENT ADMINISTRATION

Memorandum by the Overseas Development Administration

INTRODUCTION

1. The Overseas Development Administration (ODA) is the Aid Wing of the Foreign and Commonwealth Office (FCO). It is the Government Department responsible for British aid to developing countries and jointly with the Diplomatic Wing of the FCO, for aid to Eastern Europe and the Soviet Union.

2. Our aim is to promote and support sustainable economic and social development and to reduce poverty, suffering and deprivation in developing countries. In pursuing our aim, we contribute to the strengthening of our relations with developing countries and to international political stability. (a copy of ODA's Departmental Statement is at Annex A). (*Annexes A-E are not printed*)

SUSTAINABLE DEVELOPMENT

3. In promoting sustainable development ODA pays particular attention to environmental issues and to the wise and sustainable management of renewable natural resources such as land, water, biological diversity and the protection of the atmosphere. However, the attainment of sustainable development requires a better understanding of management practices and technologies for the use and conservation of these resources and the complex interaction between people, their resources, their environment and their development objectives.

4. Essential elements in achieving sustainable development are:

- (i) a thorough knowledge of the extent of, location of, and biological, physical and chemical characteristics of our natural resources—both renewable and non-renewable;
- (ii) an interdisciplinary approach to research and development programmes involving all branches of science economics and policy making;
- (iii) an environmentally sound infrastructure;
- (iv) policies and financial mechanisms that promote and support the wise and sustainable use of resources, facilitate technology transfer and discourage wasteful degradation or pollution of the environment; and

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- (v) an intellectual capacity to carry out research and development work and to manage technology change.

5. The Government's approach into support of sustainable development and environmental protection overseas are set up in its booklet on "The Environment and the British Aid Programme".—(Annex B); ODA Briefing Paper 3—British Aid and the Environment (Annex C) and in the White Paper—This Common Inheritance (Chapter 4).

BIODIVERSITY

6. A key ingredient in sustainable development is the wise use and sustainable management of renewable natural resources and in particular the genetic resources and biodiversity of the planet from which come our food supplies and primary commodities eg timber, fibres, vegetable oils and opportunities to develop new products and materials.

7. Three broad levels of biodiversity are recognised; genetic varieties within species; the variety of species within a habitat and eco-system; and the variety of habitats on the planet. (see Annex D Forestry).

8. We do not know how many species there are on the planet; estimates vary between 5-10 million, but so far only about 1.4 million have been identified. Most of the uncertainty is over the numbers of species of insects which are probably of limited economic value; however some insects pose a real or potential threat to man and his crops or are useful as parasites in the integrated management of these pests (see Annex E—Integrated Pest Management).

9. Some habitats or ecosystems have a richer diversity than others eg. tropical forests, wetlands, the aquatic environment and the wildlands. Within these habitats perhaps tropical rainforest is the richest containing 80-90 per cent of biological diversity. The identification and conservation of these habitats must be a priority. (See Annexes D and F; Fisheries.)

ECONOMIC VALUE OF BIODIVERSITY

10. It is difficult in practice to quantify the economic value of biodiversity. Nevertheless, the genetic varieties within species, the variety of species themselves, and the existence of diverse and productive ecosystems are of themselves of economic importance. If a species becomes extinct it cannot be replaced so the precautionary principle is an important part of the rationale for conservation. The main cause of the loss of biological diversity is the destruction of important habitats.

11. In principle there are two types of value. Use value can be subdivided into direct use value eg using genetic variance in plant breeding or for chemical production (essential oils and medicines) and *option* values—what direct use might be made of biodiversity in future eg adapting to potential climate change.

12. Indirect use values are intrinsic or existence values eg the giant panda or the rain forest—which would have value in generating earnings from tourism or amenities.

13. For developing countries it is the direct use values which are the first priority. Future use values are less easily realised and may be of more benefit to the developed world.

14. The economic value of biological diversity is enormous—life, economic activity and sustainable development could not go on without it. However, not all biological diversity has a high economic value, some aspects will have a low marginal economic value. Hence the need to establish some priorities in the wider context of the development policies and objectives of developing countries ODA has commissioned further work on the economics and most cost effective means of conserving biological diversity report will be available in June 1991.

15. The lead in Whitehall on biological diversity issues lies with the Department of the Environment with whom we work closely in international efforts for a global convention to protect the biological diversity of the planet.

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[Continued

16. ODA have taken the following action:—

it is working to ensure that development projects are ecological, sustainable and ensure the protection of key habitats and species;

it has initiated some specific projects to conserve biological diversity in forest reserves, botanic gardens, national reserves, game parks etc;

it has assisted the World Conservation Monitoring Centre at Cambridge (WCMC) to produce a Global Biodiversity status report to be presented at the United Nations Conference on Environment and Development in Brazil in 1992 and its Tropical Managed Area Assessment;

it provides advice to developing country governments on the conservation and monitoring of their biological diversity eg in India with WCMC and helps their representatives to attend scientific and negotiating meetings on these issues;

it seeks to educate local people in conservation and sustainable use of their natural resources and to establish the institutional capacity to identify and to monitor the extent and value of their genetic resources.

17. Priorities for research are the:—

identification and quantification of the benefits to humankind of biodiversity conservation;

identification of priorities for conservation of biodiversity;

identifications of cost effective mechanisms for in situ and ex-situ conservation of biodiversity;

role of geochemical mapping and soil classification, the conservation of wildlife and biodiversity in general;

it is helping the Worldwide Fund for Nature to prepare a manual of centres of plant diversity; and the UK is one of the largest bilateral donors to the International Board for Plant Genetic Resources, one of the constituent institutes of the Consultative Group for International Agricultural Research (CGIAR).

ODA's APPROACH TO SYSTEMATIC BIOLOGY AND TAXONOMY

18. As it is ODA's function to assist developing countries in their strivings for sustainable development most aid activities are demand-led and aimed at solving specific problems or achieving specific objectives.

19. In doing so it draws extensively on the institutional strengths and diversity of Britain. However, it does not core fund any of the centres involved in systematic biology or taxonomy, but rather it commissions specific research or services that contribute towards the attainment of clearly defined development objectives.

20. To develop sustainable renewable natural resource management practices or farming systems requires a thorough knowledge of the nature, extent, location and potential of the resource base. Breeding programmes, biotechnology and genetic engineering require a detailed knowledge of the variance that is available and how it might be used in the service of human kind. Systems for the integrated management of insect pests, diseases and weeds require a good knowledge of host predator identities and relationships. The identification of new medicines, food sources, chemicals and commodities requires a systematic *approach*, but much can be achieved through consulting with indigenous people.

21. However, overall development objectives cannot be achieved single handed, they require an interdisciplinary approach. It is within these teams that the systematic biologist and taxonomist have a valuable role to play. From this it is clear that ODA will make greatest use of their skills in the areas most closely associated with economic and social development e.g. pest control, breeding and product development.

22. The rest of this memorandum deals with the specific questions set out in the request for written evidence.

SYSTEMATIC BIOLOGY RESEARCH

23. Systematic biology is concerned with the definition of phylogenetic (historical evolutionary) relationships between organisms and their classification into functionally distinct name groups; taxonomy (naming) provides the descriptive basis for this classification and researches measures of variability that facilitate such identification.

(i) *What is the utility of systematic biology research?*

24. The naming of living species and classifying them is a foundation science for all biology. Many species are clearly vital to human activity and to support and sustain development e.g. crop species, animal species, disease organisms, vector species. Their relationships to close relatives in the systematic classification enables these species to be better understood and increasingly enables their genetic principles to be used for development objectives. Without adequate identification scientific findings cannot be communicated even if

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[Continued

there are good informational systems. Increasingly as biodiversity issues and the importance of tropical animal and plant species becomes obvious, biosystematics will attain even greater importance for the global community.

(ii) *Does the need to specify particular organisms in connection with e.g. intellectual property rights, regulatory provisions etc. impinge on your work?*

25. Yes it does. In work currently under way in the interests of developing countries there is an increasing tendency for patenting of genetic principles. The ODA was for instance involved in work elucidating the mode of action of a gene that confers resistance to beetles in cowpeas. Currently the firm which patented the gene is allowing an ODA contractor to use this gene in sweet potatoes, free of charge. Additionally ODA is involved in work on salinity resistance genes and is considering intellectual property rights (IPR) implications. Clearly release of genetically engineered material into the environment will involve regulatory issues and protection of our client countries and we are regularly in touch with other agencies and multi-laterals on these matters of mutual interest.

26. Generally speaking it is ODA's policy that information and materials developed with aid funding should be wherever possible freely available.

(iii) *Is the level of UK research appropriate. If so how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?*

27. The level and appropriateness of UK research in biosystematics of *direct relevance* to ODA is difficult to gauge as our need is inevitably demand led by developing countries. Clearly work on taxonomy of wild plant species closely related to domesticated crops, under-utilised plant species, nematode species attacking crops, pest species etc is of relevance. Work in most of these fields is in progress and is funded by ODA. Recently for instance the results of an ODA commissioned study on Scale insects of the South Pacific was published in 3 volumes. The taxonomy of these species is important in terms of plant phytosanitary work. Shortly a simple guide to rice planthoppers, important vectors of virus diseases in rice, will be published by CAB International (CABI) based on another commissioned taxonomic work. We commission work on a demand led basis and consult with animal and plant systematists regularly—we have, to date, not found difficulty in commissioning work, though the recent rapid increase in demand for taxonomic service in forestry and fisheries has placed current capability under stress. It is our view that the demand for taxonomic services will possibly increase not only from UK sources, but also from the international community. It is generally recognised that UK has a formidable resource in entomology, plant science, mycology, forestry and fisheries.

(iv) *Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate eg importance in ecological/economical terms of groups of organisms; existing spread of expertise within the country; quality of resources available.*

28. See (iii), but the concepts of biodiversity and sustainability will require research in areas of biology where taxonomic work has hitherto been limited and highly specialised—marine benthic fauna, soil micro organisms, saprophytic fungi are examples. It is *very* difficult to specify taxa which might become important—often in the past science has benefited from academic endeavour, personal enthusiasm and curiosity research into little known groups members of which subsequently attain economic importance eg *Castanospermum* nut which contains a chemical which gave an important lead on work on chemicals currently being tested for suppressing the AIDS virus. As far as ODA is concerned our main guiding principle will be the potential importance of groups in terms of our goals of natural resources development, social considerations and likely effects on human and animal health. It is questionable whether for ODA's purposes a tightly drawn "national policy" would be useful, but support to biosystematics should continue and that efforts are made to train younger persons in the new skills required to utilise newer taxonomic genetic techniques. Issues such as genetic drift and "genetic finger printing" are important and should be the subject of further research. Our experience is that in value for money terms the quality of personnel available is high. The funding of this work could become an overhead on the work done for customers by competent scientific institutes.

(v) *What is the extent of our need for reference collections including foreign material (type collections, living culture collections etc) as a base for systematic research? Is provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of historic circumstances of our holdings?*

29. These holdings are fundamental to conducting accurate and useful biosystematics. Extinction rates are high and techniques should be developed which will enable genetic material to be retained in a cost effective way for future generations to use eg cryopreservation. Basic and reference collections are frequently required in conduct of natural resources research and these need checking against larger reference collections as a routine eg in the development of integrated systems for the management of pests at levels below which they can do significant damage as set out in Annex E.

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30. Recent specific examples of this were the need to recheck the identity of screw worm introduced into N Africa and the taxonomic work which was required on the introduction of parasites to control the devastating attack of cassava scale in Africa. The retention of properly curated collections in developed countries and developing countries is important for developing countries. Many examples can be cited of the loss due to civil strife or neglect in developing countries of base collections containing irreplaceable material.

31. The UK has some international centres of excellence such as the British Museum of Natural History (BM (NH)), Royal Botanic Gardens (RBG) Kew and Edinburgh, the Oxford Forestry Institute and CABI. These have paratypes and original specimens, which are in instances the only ones remaining or are unique and a legacy of our active exploratory natural history past and colonial heritage. British centres of biosystematics are part of a global network that exchange material and information. To be actively involved in networks of this type demands reference material.

32. With the rising concern for the conservation of biodiversity there will be a need to review the demands for the current capacity and the means by which it should be resourced.

(vi) What new methods are there and how will this affect UK research? Is the availability of information technology (computerised data bases) to systematic research being adequately explored? Is UK research taking cognisance of the full range of new developments in this field?

33. The advances in genetic techniques and information retrieval mean that additional research is required—ranging from detailed genetic studies through to development of software and interactive identification systems. Keys and lists need constant updating in the light of research. The scientific fraternity is taking cognisance of the new developments. Efforts to profile the issues are being made internationally and by the traditional UK sources of biosystematic information including BM(NH), Kew and CABI.

(vii) Is the current "institutionalised base of research appropriate? etc

34. This is not in the purview of ODA.

(viii) If research is continued who pays? Should burdens of expense be shared with other countries eg a UN programme? Can ESF help to rationalise activities? Within UK how much more should Government pay for and how should budgets be best protected? What role can industry play?

35. The ODA will continue to finance research when and where real need and clear objectives are identified. Given the resources required and the scarcity of qualified and skilled people burdens should be shared not only by UK sources, but also by the international community. Our experience with UN agencies is that they are often not well equipped to "manage" specialised programmes and can have difficulty in staffing such work with suitably qualified people.

36. The ODA commissions work on a reasonable and justifiable full economic costs (FEC) basis and will continue to seek out the best institutions for delivering results, ensuring that biosystematic research costs are written into project documentation. In the past we have not had to seek overseas assistance in the biosystematic field and have relied on the established networking techniques operated by scientists to obtain overseas expertise in particular areas.

37. ODA will also consider requests from developing countries for aid support to purchase services from British institutions.

(ix) Is teaching adequate?

38. In relation to developing country concerns this varies with subject area. The UK has considerable comparative advantage in certain areas—insect taxonomy, eg BM(NH), Imperial College, Newcastle and Cardiff Universities; forest taxonomy—Oxford Forestry Institute, Edinburgh University, plant taxonomy—Edinburgh, Kew, Royal Horticultural Society; Fisheries—Stirling, Swansea University (genetics). Developing countries are being encouraged to develop their own teaching capability and to develop 'link' arrangements with a UK centre of excellence. Most developing countries have been made to give high priority to their institutions in their field because of the many pressing claims on their resources. Thus for developing country nationals employment opportunities in their countries are few and career advancement problematical making biosystematics less than attractive.

(x) What can we learn from abroad, especially from the USA?

39. To the best of our knowledge the system in the US is not fundamentally different from that in UK. There are currently moves afoot to encourage a global network on biosystematics involving UK and overseas institutions. These have a relevance and utility given the necessary exchange of information, scientists and ideas involved.

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[Continued

Examination of witnesses

MR A J BENNETT, Chief Natural Resources Adviser (G3), DR J C DAVIES OBE, Deputy Chief Natural Resources Adviser (Research) (G5) and MR J PERFECT, Deputy Director, Natural Resources Institute, Chatham (G5), Overseas Development Administration, called in and examined.

Chairman

124. Mr Bennett and colleagues, thank you for coming. Thank you for your written evidence and for all the other supporting papers which you have produced. You know the nature of our enquiry, and I think you have had a list of the questions that we thought we might put to you, have you not?

(Mr Bennett) We have.

125. I wonder whether there is any general statement you would like to make beforehand and whether it would suit you to do that and perhaps have questions and answers thereafter?

(Mr Bennett) Lord Chairman, I think if I may make a few introductory remarks and then perhaps if we move into the questions fairly quickly. Lord Chairman, it might be helpful just to introduce my colleagues so you know who is in here today. Dr Davies is the Deputy Chief Natural Resources Adviser for research issues within the ODA. He has an overview of our research activities and in the commissioning in the fields of renewable natural resources and environmental issues. He also sits on international committees, the Consultative Group on International Agricultural Research and on the European Community, Science and Technology Committee for Developing Countries. Mr Perfect is from the Natural Resources Institute, an executive agency, it became an executive agency on 1st April last year. He is a deputy director and he has responsibility for all of the integrated pest management programmes and the direction of research in those areas. That covers entomology, pathology, weed science and those subject matter areas. He has published a great deal. The programmes he looks after amount to some 12 million annually. I am the Chief Natural Resources Adviser of the ODA. My job is to try and hold together the work we do, both in terms of advising our own spending departments and policy departments on their renewable natural resources policies and programmes. So it is the organisation of advisory services covering all research and the development of policy. My Lord Chairman, this enquiry of yours comes at a very opportune and timely moment. There is a great deal going on on the international field and also in the United Kingdom over concern for the world's biological resources. As you are probably aware there are negotiations in the context of the United Nations Conference on the Environment and Development which is due to take place next year in Brazil to try and develop an umbrella agreement or convention on surveys of the world's biological resources.

126. I thought somebody before referred to UNEP not UNCED? Is UNED the correct one?

(Mr Bennett) UNEP is the United Nations Environment Programme. They have a lead role in many aspects of working up action programmes. The United Nations Conference on Environment and Development (UNCED) falls under the auspices of the General Assembly and this is being dubbed as the

"World Environment Summit" and is due to take place in Brazil next year. UNEP is involved but there is a special secretariat involved in setting up that Conference, UNEP is a contributing party to that. As you are aware the Overseas Development Administration is the aid wing of the Foreign and Commonwealth Office. It is our job to try and develop programmes which are relevant and effective and give value for money. Our two main objectives are to promote sustainable economic and social developments and to alleviate poverty. In trying to sustain or develop and maintain sustainable production systems a thorough knowledge of the extent, location, biological, physical and chemical characteristics of our natural resources both renewable and non renewable is absolutely essential. Therefore, as far as biodiversity is concerned, it is a vital ingredient and one of the main armouries in developing the sustainable use of natural resources, whether it is to identify new materials or to develop resistance to pests and disease. It biodiversity is all part and parcel of the world's genetic resources. We have done a certain amount of work on the economics of biodiversity: is it worth our while? It is easy to say how important it is and that it underlies all we do, but when someone says "Can you put a value on it?". We are now commissioning economists to do further work on this, if we are to sustain our funding in this area we need to make sure we have our actions based on good economics, good science and a lot of common sense.

127. It seems to me to be very difficult for you to say what is your priority, what is the benefit of research in this area? In a sense the question you have to ask is what is the cost of not doing it?

(Mr Bennett) I think the way we come to it, from our perspective, is sustainable development; knowing and understanding fully the nature of our renewable resources. The whole aspect of systematic biology and taxonomy must be fully integrated within what we do. We do not necessarily fund specific work in this area unless it is part of an overall development programme or moving towards the solution of a specific problem. It was quite interesting, Lord Chairman, when we started to look at the numbers of research projects and country programmes we have, how many of them had an element in them for taxonomic work, classification work and systematic biology. It is well integrated and well embedded which at the same time makes it difficult to extract the precise figures of what it is we are funding although we can give lots of examples. That, I think, is probably as far as I should take it at this stage because I think probably it would be more interesting to move on to the specific questions and issues you raise.

128. Thank you very much for that statement. If I have understood it, what you have told us is in a sense it is essential to almost all of your work it is so closely entangled that it is difficult to untangle it from the cost point of view but it is immensely valuable to keep on doing it. Are you content with the resources which

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[Continued

[Chairman *contd.*]

are available to taxonomic work and systematic biology work in this country as seen from your point of view, or do you perceive lacks?

(*Mr Bennett*) My Lord Chairman, we have a great deal of respect for the enormous resource there is in this country and we do make quite extensive use of it. We have not found any major shortcomings, indeed every time the call has gone out, for the most part, we have found within the United Kingdom the type of resource we are looking for. I think there is an issue related to that, obviously our demands come in the context of specific development needs and that, as customers for those services, where they are often for fairly tightly defined activities and, therefore, we are not in the business of core funding a lot of institutions, although we are extremely happy to pay—well, we accept the need to pay—realistic overheads.

129. Thank you. Are you concerned at all as some people seem to be that the number of potential contractors and their quality is not being maintained at a level you would want, using the customer/contractor relationship implied in your earlier statement?

(*Mr Bennett*) We, so far, have not come up against any problems of capacity although to take the second part of your question there are occasions when we have recognised in order to move forward adequately we need to fall back upon some systematic biology and some taxonomy.

130. Are many of the people to whom you go for this information getting on in years? It has been represented to us it is an ageing population of people in this field.

(*Mr Bennett*) I would like to ask Dr Davies to answer this as he is perhaps more representative.

131. You mean he has more grey hair!

(*Dr Davies*) I think you have touched on a very important issue there. Undoubtedly there is the ageing factor. We have seen it with regard to some of the studies we have commissioned. For instance I know one or two people around this table know we commissioned a study on scale insects of the South Pacific and that was an example of where the person who did the study in fact was already retired. Of course, in traditional taxonomy you develop a skill over a long and protracted period of time. On the other hand, we have always tried, so far as is possible, to stimulate the demand from developing countries for activities in this area and also included in our programmes younger scientists who have an interest in taxonomy. Again, in several instances I think we could point to the fact that we have brought along younger people into the field and I think this is the only way we can go about it.

Lord Adrian

132. Do you find an increasing competence in the countries you are dealing with? Are you moving away from taking taxonomic advice in this country and getting it from abroad in the countries where you happen to need it? Is there a development overseas in taxonomy?

(*Dr Davies*) Yes. One of the things we attempt to do is to draw attention to the value of such work and

try to get the countries concerned to ask for it in their aid programmes. Certainly an additional factor through various activities in association with the CABI, the Commonwealth Agriculture Bureau International, is we do more and more 'in country' and some of the courses that have been running have been sited in developing countries which, again, increases awareness in those countries.

133. Do you fund people from overseas to come and study taxonomy here and if so to which institutions do they mostly go?

(*Dr Davies*) Mainly they come to the CABI institutes but also, of course, several of the United Kingdom universities which have taxonomic capabilities do run courses, particularly in the field my colleague has an interest in, which is pest control.

134. Do any come to the Natural History Museum?

(*Dr Davies*) No. Very few people actually come to the Museum other than in the context of the courses run by CABI.

135. You yourself use the Natural History Museum, do you, as a contractor?

(*Mr Bennett*) Mr Perfect might answer, he is one of our main points of contact and they have been very busy building an internal network in this area.

(*Mr Perfect*) Some interesting points have been raised. If I might comment about the dwindling of the resources perhaps before I return to the specific points. I think it is very important we associate new technologies with taxonomy as well as traditional techniques. I think that if we are looking at new blood in skills in the identification of variability then we would indeed see a rather large resource in the United Kingdom of young scientists who are really quite near the front edge of new molecular technologies for identification and definition of variability. I think it may be true that the traditional skills of taxonomists are vested in age and we perhaps are not developing these traditional taxonomic skills. We also have to be aware that the needs are shifting and we are exploiting newer technologies in our quest to define variability and identify organisms of importance to us. To return to the specific point raised of our links with the Museum, we do have effective links with the Natural History Museum. They are primarily in the area of insect taxonomy and they are primarily associated with the joint identification and taxonomy service that is being developed by the International Institute of Entomology (CABI) and Natural History Museum. We are looking to develop and more clearly define our working relationships.

Lord Taylor of Blackburn

136. The question I was going to ask was the question Lord Adrian put to you. Did you actually say, I think it was Dr Davies who said this, you are now using and using more overseas scientists than ever before?

(*Mr Bennett*) I think, Lord Taylor, what we are doing is trying to develop the institutional capacity of those countries to be better able to meet their own needs in country and that in order to achieve that we are involved in an increasing proportion of in

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[Lord Taylor of Blackburn *contd.*]

country training programmes. To take an example there were a couple in the last year, one in Kenya and one in Malaysia to develop that capacity because one of the things we do need to do. Where we are going to move forward on this area, is to better balance the interaction between our own institutions and those of the developing world. So that we hope that in their own projects and programmes they will be able to use increasing numbers of their own scientists while forming good collaborative links with our own institutions in this country.

137. May I go on to my next point which follows on: since you became an agency has this detracted from your previous policy or not?

(*Mr Perfect*) No. No, it has not materially affected our previous policy at all. What it has done is perhaps to clarify and focus our relationship with our parent department, that is with the ODA headquarters, in terms of specifying the kinds of demands they wish us to service. I can quite confidently say the answer is it has not affected our strategic approach to the work we have been involved in.

Lord Walton of Detchant

138. A small point on organisation and collaboration: we learnt from the National Environmental Research Council they are establishing a review group on evaluation of biodiversity. They say this will be run by NERC but with other research councils and other relevant organisations. They say they will be starting work shortly. Are you one of the relevant organisations?

(*Mr Bennett*) I think we may find ourselves talking together. We do have strong links with NERC and we have recently been looking at ways in which we can work more closely both from the centre in ODA and from the Natural Resources Institute. The answer is I think we are trying to make sure we have these working relationships and we do have to review them periodically.

Earl of Selborne

139. Dr Davies referred to the very important work the ODA commissioned on scale insects of the South Pacific. This was traditionally a taxonomic exercise of great economic importance, scale insects are of great importance. Is this the sort of work you see yourselves continuing to do or is it something you are going to have to give up because of the pressures of more immediate demand led work?

(*Mr Bennett*) We do at the moment cover an enormous range of activities. Apart from scale insects, we are looking at the salt-tolerance of wheat. In Central Amazonia, we are looking at the flora; multi-purpose tree species for agriforestry at Oxford, and in Bhutan, the flora of Bhutan, which was done in RBG, Edinburgh; we even fund work on the gene-flow of the Bermuda spiny lobster which is all part and parcel of an important industry in that part of the world. I think in answer to your question the work will have to go on and the more we deal with the sustainability the more we will need to understand the resources with which we deal and the variances we can deploy in moving towards, for example resistance to pests and diseases and so on. We

thought a little bit about whether we saw a shift of emphasis coming, whether there might be a greater shift, but the greater concern for forests and world forest resources and the biodiversity within them was one of the main stimulants to the UK Brazil initiative which Mr Patten signed there is a very strong link between Kew and various institutions in Amazonia.

140. When you are preparing your budget or Corporate Plan for future years, do you ring fence some money for this sort of work?

(*Mr Bennett*) We do not normally ring fence. What we would do is work towards a well-defined development objective and within that there would be a need to do further study. For example, in the case of the Brazilian programme; how does one help Brazil move in a direction of more sustainable management of the forest? There were three parts: one, looking at the diversity of the forest resources in Brazil; two, was the Oxford Forestry Institute looking at how you manage and sustain them; and the Institute of Hydrology, one of the NERC institutions, are leading on a project looking at the interaction between climate and forest resources. As you can see those are all much interlocked and within which there are some specific tasks to develop the flora of those areas and better understand the resources within each individual project.

Chairman

141. You did give us a fairly clear impression that you were reasonably content with the state of systematic biological research and training in this country, and you did also mention the importance of some of our collections. I notice in your Annex E, Section 8, you refer to supporting an extensive programme of taxonomic management and you refer in particular to grasshopper and termite taxonomy and yet that is precisely an area of the Natural History Museum where we understand some work has been discontinued. Is that a conflict there or have I got it wrong?

(*Mr Bennett*) I hope it is not a conflict. Can I ask Mr Perfect to give you his perspective because he has been involved in this area.

(*Mr Perfect*) The specific situation is that responsibility, or support, to the United Kingdom system in taxonomy of grasshoppers and locusts and termites has traditionally resided with our own institutions, with the predecessor institutes of NRI, but as the role of NRI has changed what we are seeing is increasing complementarity with other institutions. Now it makes little sense for an organisation, such as NRI to handle the curation. We do not have the facilities or capabilities or specialisation to handle the curation of collections of grasshoppers and termites. We feel this is more appropriate to the function of the Museum and we will buy from the Museum the skills as we need them. We are in discussion at the moment with the keeper of zoology for the transfer of termites and grasshoppers to the Museum.

142. Transfer of your material to the Museum?

(*Mr Perfect*) Yes. We have also supported one of our members of staff in the Museum in assisting in the curation of the collection.

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[Continued]

[Chairman *contd.*]

143. So you would feel quite content that you would still be able to tackle such a problem were it to come to your notice in the course of your Overseas Development Agency work by going to the Museum but nothing would have been lost?

(*Mr Perfect*) I think it would be incumbent upon us to ensure the resources needed to support the development programme are maintained.

144. To put the picture the other way round: the Natural History Museum Trustees when considering their spend for the future might be considering the ODA as a continuing source of funds in that area?

(*Mr Bennett*) We have already indicated to the Museum if they do have specific projects and programmes to consider we would be happy to discuss them, but we are in the business of supporting work that helps the developing world and that is orientated towards that target. Therefore there would be a need in any project proposal, that goes forward, to clearly identify what the objectives were and who the beneficiaries would be likely to be.

145. No sign there is likely to develop a lack of expertise and capability to respond to the needs of the kind you so clearly articulate?

(*Mr Bennett*) My Lord, where we have identified these shortfalls we actually sit down and do something about it. For example, when we moved into the environmental area in a very much higher profile we had to start developing the capacity to help us in this area and also to train our staff so they could better handle some of those issues. While we cannot say everything in the future will be adequate I think if the need is there (and I think the demand will come from the United Kingdom and one hopes internationally), we will be able to cover those areas adequately.

146. It has been represented to us by NERC that there is such a wealth of material and experts, though ageing, that perhaps the United Kingdom's resources might be augmented by funds from international sources to look after the collections and also stimulate production of people in this particular field. Are you saying you do not see that from your perspective?

(*Mr Bennett*) My Lord, no, I have given you the wrong impression if that is what you think. I think there is a reasonable prospect of international monies being put into this area, so the question is the degree to which the United Kingdom will be able to win those monies. There is a new facility created; for management by the World Bank but supervised by the United Nations Environment Programme and the United Nations Development Programme, called Global Environmental Facility; it is at the moment in its pilot phase of 1 billion dollars, we have made our contribution to this. The Fund is specifically to support global environmental work; it is primarily aiming towards helping developing countries to do that which they would not normally be able to afford or would not give sufficient priority to do in their own development interests. It is a valuable facility but it has only just been established. It may well be under the biological diversity element of this fund, a great deal more work could be funded in the area of taxonomy.

147. Could one look at this differently and come back to the Dual support system as it existed between universities and research councils? Are you satisfied there are lots of well-found institutions in the field of taxonomy and systematic research which would enable us to continue to be capable to be bidders for these resources, whether provided by you or an international agency?

(*Mr Bennett*) At the moment we have not found any problems and, indeed, we have found a lot of our institutions enormously responsive at this stage to these opportunities, but the proof will come over the next few years. We will obviously need to keep an eye on things. What one hopes is where the institutions and organisations perceive they have problems they will come and talk to us. There should be opportunities here for mutual advantage and collaboration.

Lord Walton of Detchant

148. Just a factual inquiry: You, of course, in your report, in your evidence, talk about commissioning work on a demand led basis and give some examples. What proportion of that demand comes from the old Commonwealth and what from other developing countries? Secondly, apart from commissioning the work do you find you get requests without any kind of prior knowledge from other countries to undertake research in this field on their behalf? Again, just how much of this is coming from the old Commonwealth and from elsewhere? Could you help with that?

(*Mr Bennett*) Lord Chairman, I am not in a position to give you an exact figure, however our aid programme traditionally goes primarily to Commonwealth countries and I think I would need to check the figure and let you know. The figure that is in my mind is (between 75-80 per cent to 85 per cent) of the British aid programme is spent in Commonwealth countries and obviously that is where there is quite considerable demand for assistance. In the field of systematic biology and taxonomy obviously the links within the Commonwealth forged by CAB, the Commonwealth Agriculture Bureau, now CAB International, will continue. We have been very active in the reform of the CABI and the way in which they will do business in the future, which is why they have International at the back end of their name; they can now provide services to countries other than the Commonwealth. We will give you an exact figure of how much of our aid is going to Commonwealth countries. In terms of unsolicited and surprising requests, they do come, but as our programmes are fairly well defined and prioritised they would have to be given a very high priority rating by the host government if they were to get through, because normally we have a fairly well defined system of discussing with each country the priorities of British aid programmes.

Chairman

149. We have taken some time but I have two concluding questions which end as we began on the subject of biological diversity. The first one is the range of species which are available is so enormous that a lot of people believe one should become more

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[Continued]

[Chairman *contd.*]

aware of information in the technology field in codifying this. First question: do you have an interest in this? Perhaps this is related to the point you made at one point, namely you are looking into the cost-effectiveness of research in conserving biodiversity. Could you tell us whether that research has proceeded and if you have any got any conclusions which will be helpful to us?

(*Mr Bennett*) To take the first part of your question about the importance of information and information technology and networking, the answer is yes, it is of prime concern to us. Now, we are all very aware a lot of information is not as easily available as it should be. We have one initiative under way already, it is a collaborative project between the Oxford Forestry Institute and the CABI which is putting on record all forestry research over the last fifty years on CD-ROM technology, including a database of genetic resources as well. So that is one of the first steps we have taken. Another one currently under discussion between NRI and CABI is one on integrated pest management. I wonder whether Mr Perfect could tell you a bit about it.

150. It seems to me the future lies in not only physical characteristics which enable you to identify the particular plant or animal in front of you but also in its genetic content too?

(*Mr Bennett*) Yes.

151. Are those being put together in any sequencing on any CD-ROM system?

(*Mr Bennett*) I am not certain. I do not know whether Dr Davies could answer that one.

(*Dr Davies*) We are certainly looking at the research side but not as far as I know at the moment are we putting anything on to CD-ROM in this area. It is a relatively new science as you know Chairman. We have many projects underway at the moment which are looking at the differences in the genetic makeup within species and so on. It is fairly early days at the moment.

152. You regard it as desirably ultimately to have that information?

(*Dr Davies*) I believe so, yes. The other aspect that my colleague would probably mention, both he and I serve on the IIE-Committee on research and there are some interesting developments with regard to interactive identification services there. We certainly are keeping a very close eye on this because it enables you to put your taxonomic information on to disk, call it up and also then to find out something more about the particular species that you are dealing with in an interactive fashion. Great strides are being made in this area and we see it as something which could be very important for developing countries.

(*Mr Perfect*) I would just like to emphasise the point, Lord Chairman. You raise the importance of information technology and I think what we are

really talking about here is the problem of access to information and in particular in developing countries. On the one hand we must somehow make it more easy for people to access the rather dry traditionally dusty taxonomy and present it to them in a way they can use and on the other hand we must improve our information management systems in order to interpret variability. Information technology will play a key part in this. My colleague mentioned the CD-ROM Enterprise with CABI, CABI have been developing ways of providing easier access to identification capabilities through information technology and we will be looking at this as a development of the dissemination of information in traditional ways. I think data handling and the transmission of robust methods of taxonomy in ways that improve accessibility to the user is one of our prime areas of interest.

(*Mr Bennett*) There was a second part to your question?

153. Cost effective?

(*Mr Bennett*) How could I forget!

154. Value for money.

(*Mr Bennett*) We have commissioned a series of studies in this area and I think we set out some of them in our memorandum about the type of work to be done. A lot of them are still at a very early stage, however we have commissioned some preliminary papers on the management of biological diversity, the first was with the World Conservation Monitoring Centre at Cambridge, which we part funded, on the hot spots and important areas. The second stage is to consider particular key habitats in greater details. We have also commissioned a series of papers, these are currently being edited into a booklet, which we intend to put out, hopefully, in June this year and in which are trying to define very clearly what the priorities are. As you rightly point out there is an awful lot biodiversity out there and we need to start to narrow down and prioritise where we are going to do work. This work should move in that direction. I think that it is to some extent a question of "watch this space" my Lord Chairman, but it should not take too long, at least to get the booklet out in June.

155. Thank you very much. May I thank you for coming and invite you in case you feel we have not touched on all of the points you would have liked to have made to put them in writing to us. Thank you.

(*Mr Bennett*) That is very kind. We have promised one or two additional bits of information, we will go through the questions you gave us to see if there are any issues we failed to consider fully or if we left a few bits out, when we get the evidence.

Chairman: Thank you very much.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 23 April 1991

DEPARTMENT OF EDUCATION AND SCIENCE

Miss Judith Partington and Mr John Dando

AGRICULTURE AND FOOD RESEARCH COUNCIL

*Professor T L Blundell, Professor J R Krebs, Professor R B Flavell
and Dr J N Wingfield*

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TUESDAY 23 APRIL 1991

DEPARTMENT OF EDUCATION AND SCIENCE

Present:

Adrian, L.	Porter of Luddenham, L.
Butterworth, L.	Selborne, E.
Dainton, L. (Chairman)	Taylor of Blackburn, L.
Flowers, L.	Whaddon, L.

Memorandum by the Department of Education and Science

GENERAL

1. The Secretary of State is responsible within government for support of the UK's basic science capability. This responsibility is discharged through the provision of funds from the science budget to the five Research Councils, the Royal Society and the Fellowship of Engineering; and through support for research at universities through the Universities Funding Council. The Secretary of State is advised on his responsibilities for civil science by the Advisory Board for the Research Councils (ABRC).

2. The ABRC was reconstituted in April 1990 as a smaller body with a more explicit remit to improve co-ordination and joint working among the Research Councils. It now has a full-time independent Chairman, 6 independent members chosen for their range of expertise and experience, the 5 Heads of Research Councils, the Chief Scientific Adviser in the Cabinet Office and the Secretary of State's assessor. The Board's full terms of reference are at Annex A.

3. Within this framework, it is for the Research Councils and individual institutions to decide on their scientific programmes within the resources made available to them by the Department and the UFC. It is a long established policy that the Secretary of State does not make judgments on the competing claims of scientific programmes and projects; he looks to the ABRC for advice on the allocation of the science budget and it is then for the individual funded bodies to decide their priorities within their overall resources. Accordingly the Department does not have its own scientific expertise; if the Secretary of State needs advice on a scientific issue, he draws on the expertise available within ABRC and the Research Councils.

4. This arrangement applies to research in systematic biology in the same way as other scientific disciplines. It is for ABRC and the Research Councils to judge the priority to be given to relevant research in this area compared with others and the appropriate level of funding within the resources available from the science budget. The Councils may fund work as a result of their own initiative, or through support for projects submitted by HEIs and other bodies selected for their scientific excellence through peer review. Applications from these bodies will in turn reflect their judgement about the work which should be pursued and the priority to be given to it.

5. These arrangements for funding, in which decisions are taken by individual institutions, reflect the Government's view that decisions should be taken by those best able to make them; it should be for the scientific community, as represented by the ABRC, the Research Councils and individual institutions to decide the priority to be given to particular areas of science and to particular projects. The Government considers that this is the best way of deciding between the competing claims on the inevitably limited resources which it can make available for scientific research.

Ministerial Responsibility for the Natural History Museum

6. Responsibility for the British Museum (Natural History) rested with the Secretary of State for Education and Science until 31 July 1987. It transferred to the Minister for the Arts with effect from 1 August 1987. Announcing the decision in reply to a Parliamentary Question from Mr William Powell MP, the Prime Minister said (Hansard 22 July 1987 cols 220-221):

"I have decided that responsibility for the British Museum (Natural History) should be transferred from the Secretary of State for Education and Science to the Minister for Arts. Such a change will enable this world famous museum to play its full part alongside the other great national museums and galleries in the Government's developing policies for the national heritage. It will also enhance its potential for collaboration with the other museums, particularly those in South Kensington.

I and my Ministerial colleagues concerned hope and intend that, following the transfer which will come into effect on 1 August, the museum will maintain and develop its distinguished scientific standing and strong working links with the scientific community. The Royal Society will continue as now to advise on the appointment of one member of the trustees; this advice will in future be given to the Minister of Arts. In addition the museum will be eligible to apply in future on a competitive basis to the bodies

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[Continued]

funded from the science budget for research grants and awards allocated by normal peer review procedures."

7. As envisaged at the time, staff at the Natural History Museum can apply for science budget funds from the Research Councils. These are considered in the same way as applications for support from researchers in higher education institutions. Individual Research Councils can also take an overview of the research in systematic biology relevant to their responsibilities. In so far as there are areas of overlap between Councils, the ABRC now has a specific remit to promote effective collaboration between the Research Councils and the harmonisation of their activities. The Committee is receiving evidence separately from the Councils on how they undertake these functions, and will be aware of the proposal by the NERC Council to support a new strategic review of national requirements for taxonomy, to be run by NERC but with the involvement of other Research Councils and relevant organisations.

Teaching

8. The Committee also asked for evidence on the quality of teaching in systematic biology. The courses to be offered and the content of curricula in higher education institutions are matters for the institutions themselves, as is the maintenance of appropriate teaching quality. For universities the CVCP has recently set up its Academic Audit Unit to provide assurance that institutions have adequate quality control systems in place. In the PCFC sector, the CNAA has been influential in monitoring the development of quality control systems through its powers to accredit institutions to award CNAA degrees and to approve courses for awards.

9. Teaching in PCFC institutions is also assessed by Her Majesty's Inspectors of Schools, who report on individual institutions and also write reviews of specific areas drawing attention to good practice and any deficiencies which should be addressed. HMI report that the teaching of the traditional aspects of systematic biology (taxonomy, morphology) is satisfactory, although there is relatively little activity in this field in the PCFC sector. There is more and growing activity in the related field of molecular genetics, where teaching is generally good.

TERMS OF REFERENCE FOR RECONSTITUTED ABRC

1. To advise the Secretary of State on his responsibilities for civil science—with particular reference to the Research Council system and its articulation with higher education, and the proper balance between national and international scientific activity;

2. To advise the Secretary of State on the resource needs of the Research Councils, Royal Society and Fellowship of Engineering, and on the allocation of the Science Budget between these bodies.

3. To promote effective collaboration between the Research Councils and the harmonisation of their activities, and to advise the Secretary of State on any necessary transfers of responsibilities between Councils;

4. To work closely with the UFC AND PCFC on issues concerning the support of research in higher education institutions, and the training and support of postgraduate students;

5. To promote effective collaboration between Government Departments and Research Councils in the development of both their forward strategies, and in arrangements for commissioned research;

6. To promote productive interaction between the Research Councils and the users of the research which they support.

Examination of witnesses

MISS JUDITH PARTINGTON, Head of Division B of Science Branch, MR JOHN DANDO, Principal (Grade 7), Science Branch, Department of Education and Science, called in and examined.

Chairman

156. Good morning, Miss Partington and Mr Dando. Thank you for coming, and thank you too for the written evidence which we have looked at with interest. I do not know how you think we could best proceed. There seem to me to be two non-mutually exclusive alternatives, and that is you might wish to make a statement or we could go straight on to your own evidence and the questions. It is entirely up to you. If you would like to make a statement, please do so.

(Miss Partington) I do not wish to make a full statement, my Lord. It may be helpful if I just explained to the Committee how Mr Dando and I fit within the Department. You have had our evidence

which explains the arm's length relationship which the Department has with the Councils and the higher education institutions, and explains that for that reason the Department does not have its own in-house scientific expertise, so Mr Dando and I are not experts in systematic biology. We are here because my division within the Department has responsibility for co-ordinating overall science policy and for the structure of the system—organisational issues such as the respective responsibilities of the Research Councils and the ABRC, and also other structural issues such as the dual support system for supporting scientific research in universities. That might help to put in context why we are here today.

157. Thank you very much. That also provides a useful peg, because the arm's length principle seems

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[Continued]

[Chairman *contd.*]

to relate to a very long arm indeed, to judge from your evidence, and perhaps it might be worthwhile talking about that to begin with. I notice you say, "The Secretary of State is advised on his responsibilities for civil science by that the ABRC." Is he not also advised by the universities which have a national science base, in which we are interested, and which receive funds from the Department which are applied to scientific research?

(*Miss Partington*) Yes, of course, he also receives advice from the Universities Funding Council on the university side.

158. As part of the bid?

(*Miss Partington*) As part of the arrangements for funding of the university system, yes. Of course those two are brought together within the Department, and you will have seen the ABRC itself has as part of its remit, which was attached to our written evidence to the Committee, responsibility for working with the UFC.

159. Yes, that is very interesting, though in fact a means of doing that most effectively which you mentioned, namely to have the chairman of the UFC as a member of the ABRC, has been removed?

(*Miss Partington*) I know, my Lord, that that was one of the recommendations of the recent report from the main committee, and of course the Department is looking at that very carefully and will be making our response. I do not think I can comment on what that will be today.

160. Thank you very much for that. I hope we shall hear of any decision which the Department comes to as soon as it is made, since, I think it is fair to say in the presence of the Chairman of the main Committee, we attach a great deal of importance to that.

(*Miss Partington*) That is noted.

161. Perhaps one could go on to another point you make, which is that the Secretary of State "does not make judgments on the competing claims of scientific programmes and projects." Does it not constitute a judgment on these policies when he is trying to arrive at a figure for the support? It seems to me very difficult to go to a shop and say, "Well, all I am going to buy today is limited by the poundage in my pocket when I need certain things for various purposes which may carry me over that?"

(*Miss Partington*) I think, Mr Chairman, in a sense it is an iterative process. The councils and the ABRC themselves rank the scientific work they would like to see done in priority order. They advise the Secretary of State on the basis of that priority order what they would like to be able to do if a certain level of funds were available. The Secretary of State looks at that and decides how much the country can afford to make available for scientific research. In that sense the Secretary of State is not himself making the judgment about which are the programmes which should be funded; he is making a judgment about how much money should be provided overall.

162. But when the position is such that what can be done with the people we have is in fact much greater than resources will allow, then of course the level of

resources does in fact carry an implication about what can be done.

(*Miss Partington*) Indeed, and I think the Secretary of State has made clear on several occasions recently that it is inevitable with scientific research that there will always be a lot of potentially excellent work which simply cannot be funded, and the difficult choices are to decide which are the things which will not be done rather than which are the things which will be done.

Lord Flowers

163. It seems to me that if the Secretary of State has not yet made up his mind what the total budget for science is going to be, and he is casting his eye down the list of priorities, he must stop at something and say, "In my opinion those below the line are less important than those above." Is he not then taking a scientific decision?

(*Miss Partington*) I do not think it is fair to say that that is the way the decision is arrived at. He has to balance two possibilities. He has to balance the programme of work which the scientists have told him is well worth doing, with the possibilities for government funding and the other priorities for the use of those funds. Yes, that does involve drawing a line at a certain point and he is guided by where the scientists have told him the priorities should lie, and balancing that against how much money can be made available overall. He is not, in doing that, making a judgment, "Yes, this particular project deserves funding and this project does not", that is a consequence.

164. Let me give you an example of the sort of thing which worries me a little. I understand and accept of course the Secretary of State would not wish to take routine scientific decisions himself, indeed he could not. But if, for example, and I am being purely hypothetical, he became aware the United Kingdom could not play its part in the study of something important, let us say the oceanic fluxes of planktonic organisms—which is very important actually, and not hypothetical, for environmental reasons in connection with the carbon cycle—supposing he knew the United Kingdom could not play its part in this because of the low state of taxonomic expertise in this country, would he not wish to seek an explanation or even perhaps an improvement in the position, or is the international standing of this country of no concern to the Secretary of State?

(*Miss Partington*) The international standing of the country is of course of concern to the Secretary of State. I think if that situation, that hypothetical situation, were to arise, he would want to say to the Research Councils and to the other institutions which were involved in doing that work, is it really the case that this work is of such high priority it is having to be sacrificed and yet it has not found a place within the programme, within the funds which we have been able to make available? I think he would want to have very clear evidence as to why, if it were of such priority, it had not been done.

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[Continued]

[Lord Flowers *contd.*]

165. So you agree that the extremely long arm's length approach which your written evidence describes does not really apply?

(*Miss Partington*) Clearly the Secretary of State will want to take advice, including among others from the chairman of the Advisory Board for the Research Councils, on the state of the science base. What I think he would say was that it was not his position to go to a Council or another funding body and say "I disagree with your priorities, I think that you should be funding X rather than Y".

166. Although the Secretary of State in his evidence to us did make it pretty clear that he disagreed with SERC's priorities, which had led to a gross underfunding this year of research grants and studentships, he may not have taken any action on it. Perhaps he should have done!

(*Miss Partington*) I think that is more a decision for the Science and Engineering Research Council.

Lord Butterworth

167. Listening to what you said, does it mean the competition, as it were, in the Secretary of State's mind is between how much should go globally to science and how much, for instance, should go to the schools or how much should go to the universities? Is that the kind of issue that the Secretary of State would think was appropriate for him, rather than getting into the details of the science programme?

(*Miss Partington*) Yes, my Lord, in the sense clearly that those are decisions the Government collectively has to take and that he as Secretary of State for Education and Science has to take.

168. So he might think in a particular year "This is a year when we must provide more for schools because of where we have got to with the national curriculum", or whatever it may be, but at his level he would not be concerned with what the borderline was as to what fell inside or outside the science programme?

(*Miss Partington*) I think that would be a fair description, yes.

Chairman

169. Possibly you know that the NERC thinks the time has come for a review of systematic biological research and is contemplating undertaking one. Is this a matter which receives the approval of the Department or does it just stand back from it?

(*Miss Partington*) We are obviously interested to see that that is happening and pleased to see that it is a reflection of a Council looking across its responsibilities and taking action. I understand that the Chairman of the ABRC was also involved in the original initiative to set up that review. I think that will watch its progress; we will not be directly involved in it.

170. Returning now to this problem of the dual support system to which you referred, and coming back to the subject of systematic biological research, one of the main centres of this research is, of course, the Natural History Museum which is not funded by the DES any more, as you pointed out in your submission; but when it was transferred to the Office

of Arts and Libraries it became eligible to apply to the Research Councils for grants for its scientific work. Would the ABRC, as it were, be having that close relationship with the Natural History Museum since it is the other partner in this dual funding arrangement that it has, or should have, with the UFC?

(*Miss Partington*) I am told it certainly has continued to keep in touch with the Natural History Museum. Sir David Phillips last year organised joint discussions with the Chairman of Trustees of the Natural History Museum and the Chairman of the Natural Environment Research Council. He with others looked at its corporate plan and at its plans for research; so, yes, the ABRC has continued to have, as it were, a watching brief in that area.

Lord Flowers

171. Who looks after the well-found laboratory aspect of the dual funding system in the case of the Natural History Museum, the OAL?

(*Miss Partington*) The Natural History Museum itself. The arrangement within the dual support system is that the institutions—normally the universities, but in the case of the Natural History Museum the museum itself and its trustees—would receive block funding for all of their activities. It is up to the institution itself how it deploys that block funding. That is exactly the same: a university has to decide how it will spread its funds between teaching and research in just the same way as a museum would have to decide how it would use its block funding.

172. Indeed, yes, but in the case of universities one knows the calculation the UFC does and what part of its money is intended—not compulsorily—for research. In the case of the Natural History Museum, how does the OAL know how much to allow for research?

(*Miss Partington*) I think that that is not quite an accurate way of looking at it in the sense that in allocating its funds the Universities Funding Council includes several research-based criteria, and the amount an individual university gets flows from that formula involving those criteria, amongst others, but it is still for the individual university to decide how it then spends its funds. I think that...

173. That is not my question.

(*Miss Partington*) I think with the Natural History Museum, because it is funded amongst a much smaller group of institutions, there is not an equivalent funding formula and funding will tend to be based on the case that the Natural History Museum makes to the Office of Arts and Libraries. To the extent that a direct relationship in that way rather than funding through a formula may allow the institution concerned a much better opportunity to make its case, I think that it is reasonable to assume that the Trustees of the Natural History Museum can make their case for research funding in the same way as they can make their case for funding other aspects.

174. You would agree that the OAL has no capability for scrutinising that case and deciding whether too little or too much is being offered?

(*Miss Partington*) I have no way of judging that, but I have reason to think...

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[Continued

Chairman

175. Nor according to the evidence has the OAL.
(*Miss Partington*) I should perhaps say here that the well-found laboratory concept has caused a great deal of trouble within the university system and it is because of that...

Lord Flowers

176. You are telling me!
(*Miss Partington*) It is because of that...

Chairman

177. Is that a euphemism for the fact that it no longer exists.

(*Miss Partington*) It is not a euphemism for that. It is a description of the situation we seem to have arrived at where nobody actually knows what it means.

178. You surprise me.

(*Miss Partington*) The reason why the Secretary of State has recently announced changes to the dual support system for funding university research is to avoid confusion, which appears to have arisen at the boundary, over what the well-found laboratory means. The result of the changes the Secretary of State has announced will mean that the institution would no longer be expected to provide the so-called well-found laboratory.

Lord Flowers

179. Do the ABRC and Research Councils provide for the well-found laboratory component when they give research grants?

(*Miss Partington*) In future, yes. The institution will only be expected in respect of a Research Council funded project to continue to pay the salary of the permanent academic staff at the university and to provide the premises where the research would be done. All the other costs will be met by the research councils.

Chairman

180. That means the sum it is proposed to transfer must have been accurately costed as reflecting those costs and yet it is a nice round sum, as I recall it.

(*Miss Partington*) In announcing the estimate last year, when the Secretary of State announced the change, he noted that further work was needed in order to ensure that the estimate was reasonably accurate and that all preparation was done. It was a transfer based on his current best estimate and he made clear that he would make an adjustment to that in light of further work that he had commissioned from the Research Councils and from the Committee of Vice-Chancellors and Principals. They have been undertaking that further work.

181. What would the expectation be therefore in regard to systematic biological research? Some corresponding transfer of funds would be taken from the OAL into the Research Councils?

(*Miss Partington*) I think we will almost certainly regard that as *de minimis*, my Lord. In theory that would be the case, yes.

Chairman] Perhaps we can return to that. We have been going a little far from the main theme of

systematic biology research, but that is almost inevitable.

Lord Porter of Luddenham] Before we leave that, you described at the beginning how the Secretary of State manages to keep everything at arm's length by having a list of priorities given to him by his scientific advisers, particularly the ABRC and so forth. However, from what we have just been saying I do not understand where the Natural History Museum's systematic biology research is assessed compared with all the other research for which money has to be found. It is not of course by the Secretary of State for the DES. Who does look at this research compared with the rest of British research?

Chairman

182. Before you answer that, may I link to that the fact that in 1979 the ABRC did a survey of taxonomic research and produced various recommendations, and perhaps in answering Lord Porter you could tell us what account has been taken of that and what action has been taken?

(*Miss Partington*) I do not think I would like to try now to go through all the recommendations of that report; they were directed at a wide number of different bodies. In answer to Lord Porter, there is the possibility for the work of the Natural History Museum to be looked at in the wider context of the Government's co-ordinating arrangements for science. There are a number of other departments which have an interest in its work as well as the research councils and the DES. So it is perfectly possible for its work to be looked at through the central co-ordinating machinery which is organised through the Cabinet Office and the Chief Scientific Adviser in the Cabinet Office, and that has happened from time to time.

Lord Porter of Luddenham

183. So it would be the Cabinet Office who ultimately had responsibility for putting the systematic biology research in the NHM in this list for which the Government has money to fund?

(*Miss Partington*) I think it would be for the Cabinet Office to look at its overall place, yes, and if necessary to influence the decisions and the action taken by the Office of Arts and Libraries in relation to the Natural History Museum.

Chairman

184. Would it be a matter of concern if it were to transpire the new funding arrangements for the NHM—and by “new” I mean those introduced as referred to in your evidence—did not produce an adequate base from which that institution could bid for effective research funds from the Research Councils? Who would examine this?

(*Miss Partington*) I think it would be a concern. I am told by the Chairman of the ABRC he did himself look last year at the new corporate plan of the Museum and satisfied himself that there was sufficient commitment there to sustaining the research base at the Natural History Museum and there was not a cause for concern. We were looking in that way to our scientific advisers on the ABRC and the Research Councils.

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[Continued]

Lord Flowers

185. May I try and clear up one doubt in my mind? If we are talking about research activity, and let us keep to the Natural History Museum and their research activities, the OAL is responsible in general for the funding of the Natural History Museum, and the DES was responsible through the Research Councils for research grants and so on. Does the DES ever speak to the OAL about this problem?

(*Miss Partington*) We have informal contacts with officials. We do not have any regular arrangements for co-ordinating with them.

186. You have not discussed the research base of the Natural History Museum with the OAL?

(*Miss Partington*) I think our view would be it is much more sensible for the trustees and the staff of the Natural History Museum to talk directly to their opposite numbers in the Research Councils, and also to talk with the ABRC, and we would expect to get advice that way and feed that back if necessary to the OAL.

Chairman

187. It would be the responsibility of the trustees if they felt their science base was inadequate to make representations to the OAL?

(*Miss Partington*) Yes.

Lord Adrian

188. Throughout the evidence which we have received, there is I think a strong suggestion that the amount of education available in systematic biology is very limited at the university level, but I was really going to ask to what extent is systematic biology—and I mean by that the diversity of nature and the relationships of animals and the plant kingdom—featuring in the national curriculum now and, if so, what aspects of systematic biology are represented there?

(*Miss Partington*) I am not an expert in those areas, my Lord. I would not like to try to get into the details of that. The national curriculum clearly has been developed in order to give pupils a broad and balanced grounding in biology.

189. I am really asking whether in the view of the developers of the national curriculum, systematic biology is part of a broad and balanced view of biology?

(*Miss Partington*) In the view of the Inspectorate, yes, they see it strengthening the work on classification in primary schools and a teaching in secondary schools of the relevant aspects of systematic biology. The aim is to provide an overall grounding in biology, which means pupils will know enough to be able to choose to go on in any particular area, including systematic biology, beyond 16 and into the higher education system, if they wish. That is the aim of the national curriculum, to provide a broad spread of sciences so we do not have the situation that we have, or sometimes had in the past, where many pupils had no science or only a very limited area of science they were required to study.

Chairman

190. In the final paragraph of your report, reference is made to the sector which is funded by the PCFC and that is the sector to which Her Majesty's Inspectorate have made their report, is it not?

(*Miss Partington*) Yes.

191. Would that report be available to us, because it is a very surprising statement that all is satisfactory in that sector when we have a lot of evidence it is not so satisfactory in the university sector.

(*Miss Partington*) I think, my Lord, as we have said in the evidence, HMI have stressed the amount of teaching in this area, in the PCFC sector, is fairly limited; it (systematic biology) has mainly been taught in the university sector. I do not know the answer to your specific question. I will find out if we can offer something else to the Committee.

192. If they have found a better recipe on taxonomy and morphology in that sector, one ought to know about it and see it is done in that way elsewhere.

(*Miss Partington*) I could not comment on that, I am afraid.

193. Would you inquire whether the report is available?

(*Miss Partington*) I will inquire whether we can offer the Committee that information.

Lord Butterworth

194. One of the problems that I think your evidence has opened up for us is largely due to this, what I might call, "distance theory". Am I right in thinking that this is applied increasingly? Let me give you one example. The Universities Funding Council had the name of the Universities Grants Committee, and it was changed by the DES because it was intended that the Funding Council should not have that particular concern about the universities but would merely be the conduit pipe through which money passed to the universities, and it was then up to the universities to make the best they could with the grants they had received. I ask this for a particular reason, if the dual funding system is changed as you have described it, it may be that the universities will be left with so little money that they will not be able to fund laboratories to train new research scientists, younger people who have not established a reputation that they can themselves apply to the research councils, they can only be looked after by universities. Who is responsible for this kind of care? Is it the individual universities or is it the Funding Council? Who is responsible for bringing this to the notice of the Secretary of State?

(*Miss Partington*) My Lord, the universities have always been responsible for deciding how to deploy the funds made available to them. The Secretary of State in deciding the overall funding of the universities has to take account of the way in which they will on average use those funds and the purposes for which the public funding is given. One very important reason for the dual support system is precisely to ensure that universities have funds to be able to support research of their own choosing and to bring on young scientists in the way that you suggest. I think that the Secretary of State in making decisions about the changes within the dual support system

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[Continued]

[Lord Butterworth *contd.*]

would obviously want to look very hard at the evidence from the university system about the level of funding that they need to enable them to do that side, to perform that part of their function. The change that is being proposed ought not to affect that because it is transferring money which the universities have already been putting into Research Council supported work. In other words, the overall financial position would not be changed and there would still be very substantial funds going to the universities for research through the UFC. The responsibility for advising the Secretary of State on the needs of the university system rests with the Universities Funding Council.

Lord Butterworth] That is the point I was getting at. That is why I referred to the change of name. There does seem to be an implication (it is all part of the distance theory) that, whereas under the University Grants Committee the Committee would itself have taken a lively interest in the training of young scientists, the Universities Funding Council is—and I used this phrase—the conduit pipe through which funds flow and has a less lively regard for these important academic questions.

Chairman

195. I would add to that that it has, of course, lost all its subject committees which were the means of informing itself, with the exception of one—the medical committee.

(*Miss Partington*) I do not think it would be right for me to comment here on the way the UFC has discharged its responsibilities. What those responsibilities are and the relationship with the Secretary of State were set out in the Education Reform Act which also changed the name. I think it would be fair to say that the change in function was not brought about as a result of a desire to change or to develop a more arm's length relationship. There has always been an arm's length relationship. The universities justifiably, I think quite rightly, defend that freedom and wish to have discretion over how they conduct their affairs. As I said, I think that the relationship between the Department of Education and the Universities Funding Council is as set out in the Education Reform Act. I do not think I can comment further than that on the way in which in practice the UFC has undertaken its responsibilities.

196. Thank you very much, Miss Partington. Might I just summarise what I think you have been saying to us so that you could correct me if you wish to do so. The impression I have gained is that the Department's view is that on scientific matters of this kind it is primarily for the ABRC and it is for them to get views, of course, from Research Councils and where they will and from the UFC on any subject within science, and it is their duty to advise the Secretary of State and it is for this reason that the

Department takes very much a stand-back position until something is raised with it by that mechanism: is that the case which you are putting to us?

(*Miss Partington*) Yes, I think that is a fair description.

Earl of Selborne

197. Could I pursue that a little further, at risk of taking a hypothetical situation. From what we heard from the evidence today and, indeed, earlier, it is clear that systematic biology pervades a wide area of government departments and, indeed, of industry and certainly of scientific collections. We have heard not just from the Research Councils but from the Scottish Office, the Home Office and MAFF, all of whom have responsibilities for some of the collections and for funding part of the systematic biology work. It is equally clear that the new arrangements, be it for ABRC or for UFC, clearly did not have in mind—why should they?—systematic biology when they were put in place. In so far as the new structures may be seen not to meet adequately the needs of a science which needs a lot of longterm curatorial work and longterm support in a way which the research councils would describe as not greatly innovative, it is clearly necessary from time to time for somebody to review the overall position. Now, you have mentioned that in the case of the Natural History Museum you feel the Chief Scientific Adviser in the Cabinet Office might have a role. Would you see that the DES itself has any role, given that it is responsible after all for science, also to act in this capacity?

(*Miss Partington*) I think we would have a role in ensuring that where co-ordination was necessary across the Research Council system and more widely, particularly involving higher education institutions, action was being taken to provide that co-ordination. It was because of concerns about co-ordination across the Research Council system that the Advisory Board for Research Councils was reconstituted with a very specific remit to promote collaboration and harmonisation. I think the Department's role is to see that there are structures there which can perform that co-ordinating function and to see that those structures are working. It is not the Department's role actually to undertake the co-ordination itself.

Chairman

198. Miss Partington, would you or Mr Dando want to add anything to what you said or do you feel we have not covered the ground adequately from your point of view so that you would want to make any further remarks?

(*Mr Dando*) I have nothing to add, my Lord.

(*Miss Partington*) No, my Lord.

Chairman] Thank you very much indeed for coming. We are most grateful.

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[Continued

AGRICULTURAL AND FOOD RESEARCH COUNCIL**Memorandum by the Agricultural and Food Research Council**

1. The Agricultural and Food Research Council (AFRC) provides the UK with an internationally competitive research and training base in all sciences underpinning agriculture and food; including non-medical biological sciences, biotechnology and engineering. The Council's research and training is carried out in its own institutes and through research grants, studentships and fellowships in UK Higher Education Institutes (HEIs).

2. The AFRC is pleased to be able to supply evidence to the Select Committee on Systematic Biology Research. The area is pervasive and of high importance, but has struggled to receive support because of a low innovative record. The injection of new techniques such as molecular biology and information technology could revitalise the area.

AFRC for its part has supplied or housed a number of genebanks and collections at its Institutes and elsewhere (Annex 1). The increasing concerns over environmental, food safety and animal health and welfare issues, have highlighted the need for good underpinning of systematic research. Systematic biology also underpins the use of molecular biology in understanding the processes in organisms, in directing beneficial modifications within organisms and in assisting the risk assessment of releasing genetically modified organisms to the environment.

The AFRC programme of research covers the systematic classification of whole organisms, genome mapping, gene sequencing, the development of restriction fragment length polymorphism libraries. It has relevance for both conventional and transgenic selection and manipulation of genes through breeding programmes.

3. The Council has prepared responses to each of the Select Committee's questions as follows:

Question 1: What is the utility of systematic biology research?

A profound knowledge of the taxonomy of organisms underpins all aspects of biology. The following are examples of the importance of systematic biology, in relation to AFRC's goals and research programmes:

(a) Conservation of biodiversity

Biodiversity cannot be quantified without knowledge of the taxonomy of organisms. Studies on ecology, population spread and interaction, and biological control strategies all depend on systematic biology to identify and follow the organisms in questions. Of particular current interest is the impact of environmental stresses on the survival and spread of organisms.

(b) Micro-organisms

Human, animal and plant health strategies all depend on controlling microbes. These in turn depend on identifying the pathogen which causes a disease, often at a microtaxonomic level, so that specific counter measures can be taken. It is also necessary to understand how pathogens mutate and relate to each other, so that future disease problems might be anticipated and sensible remedial measures developed. Of particular topical relevance are the search for the causative agents of BSE and an understanding of the development, mutation and control of food pathogens.

(c) Identification of Useful Genes

A knowledge of specification in plants and animals is critical in identifying suitable sources of variation for tolerance towards pests, diseases and other stress responses. Specific genes in some plants, animals and microbes may also be important sources for pharmaceuticals or for food with enhanced quality and nutrition. Gene banks are therefore necessary to preserve biodiversity and to retain the potential for new wealth creating material and processes for the future.

Question 2: Does the need to specify particular organisms in connection with, eg intellectual property rights, regulatory provisions etc, impinge upon your work?

The nation needs systematic descriptions of organisms down to the molecular level in order to protect intellectual property residing in products obtained from both conventional breeding programmes (through plant breeders rights) and from the new transgenic methods (where a particular gene or gene construct might be patented). Systematics also assists the development of rapid and specific diagnostic tests for organisms such as food pathogens. Micro-organisms used in commercial processes, for example in fermenting cheeses, also need to be unambiguously classified. In addition, any use of transgenically modified organisms will require prior comprehensive risk assessment, which can only be derived from knowledge of population dynamics based on systematics.

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Question 3: Is the level of UK research appropriate. If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?

The area is international by nature. Nationally, it ranks poorly in relation to other biological disciplines. It has declined over the years, because it has often been ranked low on the innovative scale by research councils. Fortunately, taxonomy is not a static field and new techniques outlined in more detail below under Question 6 have revolutionised traditional approaches. It is important that active research is supported to underpin important areas such as ecological, health, safety and animal welfare issues. The AFRC for its part has vigorous research programmes associated with the collections it houses. These benefit from the major investment that the Council has made over the last 10-15 years in molecular biology.

Question 4: Is UK research in the right areas? Are there guiding principles that could help a 'National Policy' within which the existing facilities would operate eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?

This is a very difficult question to answer. The UK has a number of adequately resourced germplasm collections. However, it is vital that these receive assured long-term support so that researchers have the necessary confidence to continue to contribute to the collections and interact with them through active associated research. It is also difficult to pick out specific areas for emphasis, although molecular ecology relating to impacts of environmental change and perhaps development of modern fungal systematics deserve special mention. It is however clear that the major laboratories concerned with systematic biology must assimilate the modern techniques of molecular biology and information technology if they are not to fossilise.

Animal biodiversity has traditionally been a UK strength in agriculture. Many important gene sources have been dispersed worldwide from the UK, often without adequate recompense. The Rare Breeds Trust is one of the few organisations that seeks to preserve gene pools for cattle, sheep, pigs and poultry.

None of the gene banks in the UK pays its own way and properly relies on government funding. Development of a national policy on gene banks should include long term support for the collections themselves, associated research programmes, supported perhaps on a competitive basis to ensure dynamism and clear guidelines on who manages, owns and benefits from the exploitation of the contents of gene banks. Such a national policy should be developed, taking due regard of national policies within other countries, particularly within the EC.

Question 5: What is the extent of our need for reference collections including foreign material (type of collections, living culture collections, etc) as a base for systematic research? Is provision for their storage and curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?

The need for reference collections is growing with the advent of gene mapping and the discovery and identification of new genes. However, a number of UK collections are weak in terms of state-of-the-art systematics research. Care is needed that reference collections do not swallow up scarce resources which may be better deployed elsewhere. The collection should be accessible, with content information computerised and widely available.

AFRC has need of and maintains a number of collections, eg microbial, viral, arthropod, nematode, organisms of the phyloplane and rhizosphere, food and animal pathogens, wheat, barley, oats, pea, other vegetables, arabidopsis, antirrhinum and animal gene pools. As indicated in our answer to Question 8, AFRC maintains the world reference laboratory for food and mouth disease. The collections have developed within individual institutes, are associated with active research programmes, and are used extensively by UK Institutes, Universities and commercial companies. In addition, a range of overseas organisations use the collections.

Question 6: What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research cognizance of the full range of new developments in this field?

A number of new techniques are now capable of transforming systematics and must be fully exploited by the UK. These include the new techniques of molecular biology, eg genome mapping, DNA/DNA hybridisation, genome sequencing, use of PCR, gel electrophoresis, gene probing. Considerable strides have also been made in retrieval and analysis of information in databases, although UK collections have some way to go in adopting these. The new methods in themselves do not remove the intellectual problem of classification, but can considerably aid the intelligent researcher.

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Question 7: Is the current 'Institutionalised' base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?

The Council believes that the 'institutionalised' base for the UK collections is the correct strategy. The proximity and daily interaction with experts and scientists is plainly of value for progressive and aggressive curation. Countries which have adopted a centrally organised approach (eg, Netherlands, Germany, USSR, USA, Japan, Korea) have derived some organisational benefit, but at greater bureaucratic and administrative cost, whilst distancing their collections from research.

The funding is not secure. AFRC collections are in the main working collections and need sources offunding for maintenance, data collection, cataloguing and research and exploitation. The NHM also needs to secure funding to link collections with active research programmes. A national strategy is required which determines Departmental responsibilities for these different elements of funding and ensures support and take-up by industry. This might be developed through Cabinet Office scientific committees.

Question 8: If research is to be continued, who pays? (i) should burdens of expense be shared with other countries—eg, a UN programme? Can ESF help to rationalise activities? (ii) within UK, how much more should government pay for and how best can budgets be protected? (iii) what role can industry play?

- (i) There are considerable advantages in maintaining strong national collections. Funding through EC or UN may be just as expensive to member states, but less accessible to national users. However, the world reference laboratory for foot and mouth disease is successfully housed within the AFRC Institute for Animal Health at Pirbright and is sanctioned by both FAO and OIE to manipulate all seven sero-types of FMD. IAH is under a contractual obligation to FAO and EC to continue to maintain its reference collection.

The EC or the European Science Foundation may also be able to bring together support, perhaps for using national collections in a more coherent way.

- (ii) Systematics is a long term activity and requires secure funding from government. Two elements of support are required, for infrastructure and for research connected with the collections. Departmental responsibilities should determine the level of support for each.
- (iii) Industry is prepared to pay towards some collections—for example, ICI supports the vegetable gene bank within the Horticultural Research International. However, industry support is likely to be piecemeal and selective, and therefore unlikely to provide the long term stability of funding required.

Question 9: Is teaching adequate?

Teaching of systematic biology in UK universities has taken a very low profile in recent years and good students are not being attracted into the area. From a strong position of 25 years ago, Britain is now well behind the US in many areas of research in taxonomy. Strength must be increased, especially in university teaching. Interest might be heightened by incorporating into school curricula the concept of gene pools and biodiversity. At the post doctoral level it may be appropriate to introduce a Fellowship scheme.

In terms of analysis and utilisation of germplasm, the UK is probably as advanced as anyone, but the effort is fragmented and of an uneven depth.

Question 10: What can we learn from abroad, especially the USA?

The US has centralised collections and therefore has a clear focus for attracting funding. The UK needs a national policy with clear departmental responsibility for the support of systematics and gene banks. Greater investment in research allied to gene banks would provide both intellectual and industrial benefit.

At a more practical level the UK should study the techniques of analysis and data handling adopted by others to ensure that UK methods are the most up-to-date in the world.

LIST OF GENE BANKS AND REFERENCE COLLECTIONS WITHIN AFRC INSTITUTES AND UNIVERSITIES

<i>Institute</i>	<i>Collection</i>
1. Institute of Plant Research	AFRC Small Grain Cereal Collection Wheat and Related Species Collection Pea Collection Hordeum Spontaneum Collection Field Bean Collection
2. Institute of Arable Crops Research	Willow Collection Nematode Collection

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<i>Institute</i>	<i>Collection</i>
3. Institute of Grassland and Environmental Research	Oat Cereals Collection Ryegrass Collection White Clover Collection
4. Horticulture Research International	Hop Collection Edible Mushroom Collection Prunus Collection Hardy Ornamental Nursery Collection Farm Woodlands Collection Vegetable Gene Bank
5. Institute of Food Research	National Collection of Food Bacteria National Collection of Yeast Cultures
6. Institute for Animal Health	World Reference Laboratory for Foot and Mouth Disease Virus
7. University of Nottingham	<i>Arabidopsis</i> Seed Resource Centre

Examination of witnesses

PROFESSOR T L BLUNDELL, FRS, Secretary to Council, PROFESSOR J R KREBS, FRS, Professor of Zoology, Edward Grey Institute of Field Ornithology, University of Oxford, PROFESSOR R B FLAVELL, Director of AFRC Institute of Plant Science Research John Innes Institute, Norwich and DR J N WINGFIELD, Head of Science Division, Agricultural and Food Research Council, called in and examined.

Chairman

199. Thank you very much for coming to see us and thank you too for your written evidence which we found very interesting indeed. I wonder whether you would like to make any kind of general statement and emphasise particular points in your evidence, or indeed any additional points which may have occurred to any of you, at the beginning or whether you would like to go straight into the questions? You have tried to address all the questions which were put. It is entirely up to you.

(*Professor Blundell*) Thank you very much, Lord Dainton. Perhaps I could make a general comment, a short one, to begin with? You will all know that the AFRC has a remit to support that biological and engineering science which underpins agriculture, food and biologically based United Kingdom industries, and we fund scientists in institutes, universities and polytechnics. The question of support for biological systematics by our Council has caused some discussion amongst our scientists in the Institutes and University groups. It is really a question of definition. I wonder if I could discuss this briefly to begin with? We assumed you did not mean taxonomy. In fact there are very few scientists funded by our Council who would admit to being taxonomists; that is being interested in relationships between species just as a matter of intellectual curiosity. True taxonomists number less than 10 amongst our 3,000 employees. Nevertheless, we assumed that you have included in your definition of biological systematics the collection of species, their classification and also of course the general study of phylogenetic relationships of organisms, even if these activities resulted from broader, often more strategic and sometimes applied objectives. If one bases biological systematics on that definition, then almost every member of our Research Council is in some way contributing. Probably there are more than 50 man years of work, using these wider definitions.

It might be worthwhile just looking at the history of our involvement under that definition. The

objectives which we have in our Council have led to a very broad interest in collections, as you can see from our answers. These started often from interests of plant and animal breeders, mainly in the study and maintenance of biological diversity. We have a range of collections numbering more than 20; there are collections of peas, rye grass, wheat and many others mainly in the plant area. We have also been interested in collections of pathogens. That has been a traditional interest of epidemiologists of both animal and plant diseases, and of course in food poisoning. We have as a consequence collections and phylogenetic studies of ranges of viruses, bacteria, nematodes, protozoa and all sorts of other pathogenic organisms.

This is the traditional background, based on breeding and perhaps epidemiology. The major change which has occurred recently is the introduction of molecular biological techniques, in particular techniques like DNA sequencing or restriction fragment length polymorphisms, where one cuts up genomes with enzymes and gets characteristic patterns. This has brought a new dimension to the understanding of genetic relationships between species which form our collections, although the studies' main objectives have often been different in our institutes and university-funded groups. This research has been useful in the breeding programme; we have a new programme where we can produce transgenic plants, we can transfer genes into plants and animals, and in the coming years many of the genes we transfer will certainly come from organisms in our collections which have particular phylogenetic features. We will want to have a classification available in using this genetic information. So the production of transgenic organisms, both plants and animals, is going to be an important aspect which both supports our collections and draws support from them.

Also the typing of pathogens has been very much changed by molecular biology. For example, one can take ribosomal RNA, part of the machinery for

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[Continued

[Chairman *contd.*]

protein synthesis, and use it for typing bacteria. This can be achieved very quickly for bacteria, for example those that are important food pathogens. This of course in itself gives a tremendous amount of information about the phylogeny and taxonomy although in selected areas. It is perhaps worth mentioning here that the taxonomy of organisms like viruses, bacteria, and others which are more difficult to define by their appearance, has been revolutionised by molecular biological techniques. We now have a considerable amount of information about the genetics and genetic structure of bacteria and also of viruses; for example we have the foot and mouth disease virus world reference collection. I would like to make the point that molecular biological techniques, such as sequencing the ribosomal RNA, are broadly applicable in a wide range of scientific areas. I was looking at my own experience of where that technique is useful in classifying bacteria. It is useful for bacteria used in cheese-making or other kinds of fermentation of milk, and, in silage inoculants. There is also interest in typing bacteria for diseases like mastitis of cows, where different but related streptococci give different kinds of infections in the cow. There is also the use of the same technique in classifying rhizobium, so there are all kinds of applications of the same new molecular biological techniques which in a rather bitty way add to our knowledge of taxonomy. They really come out of our science but are contributing to taxonomy. So all of these developments in the new molecular biology and cell biology are building on the traditional interest in breeding and epidemiology and have really re-emphasised the importance of collections and classification of organisms. We believe, that we are making quite significant contributions to that area, even if, to go back to my starting point, we declare we have less than ten taxonomists.

200. What it speaks to is the pervasiveness of both classical methods and modern methods throughout the AFRC's activities and the importance of this in the applied side as well as in the theory side. The point I think we are perhaps concerned with as much as anything is whether, taken across the whole field, it goes beyond the AFRC into other research councils like NERC, to whom reference is made in your written answers to the questions; whether in the universities, whether in the Natural History Museum, the state of the science is adequate to sustain what it is necessary to sustain in this country if we are to get the maximum value out of it? That is, I think, our major concern. Would you have anything to say about that? You say you think the review such as NERC has produced is desirable, which in itself must mean you have some unease about the present state of affairs. Would you like to expand on that?

(*Professor Blundell*) I think it really derives from the statement I have just made, that because collections, and our involvement in taxonomy, has really been driven by new strategic science, we do not have a good over-view of the area. I think we are particularly poorly informed on the relationship between our collections and those of others, for example of our collections of pathogenic bacteria,

which infect breeding animals, those of the MRC that affect human health and those kept in the universities which may be of broader interest. So I think that our first statement would be that it is time to assess what we have in the United Kingdom and then to ask what networking between collections is required and where responsibilities should lie. Perhaps I could bring in Dr Wingfield on this question about how we are organised and how our work relates to other institutions.

(*Dr Wingfield*) My Lord, I believe this refers to question 8 on your supplementary list. We see that it is important to have a national strategy before we go forward into any international scene, mainly because we need to have a strong base on which we can build and then interact outwards rather than perhaps being rather reactive to the international approaches that are made. Within the national scene it is important that all of the players are consulted and take part in formulating that national strategy. Therefore, we see the need to bring together not only the research councils—which I think is the NERC approach—but also the departments, so that their interests and their policy needs are seen alongside the research councils needs in terms of research. Our aim, of course, would be to make sure there is longterm funding not only for the collections which my Secretary has outlined but also for molecular biology, the information technology that needs to go alongside with that, and vibrant research programmes that need to build on these collections. We see the need of a strategy for longterm support of the collections themselves and then perhaps a different but related strategy in building on the research.

201. Could I go a little further and ask, in view of the importance of the directions to which reference has been made, do you see that the United Kingdom has a supranational role and, if so, who should pay for that particular role?

(*Dr Wingfield*) I think the United Kingdom is in a good position, from our Council's view. The Council has a number of good collections which are related to research. In terms of who pays for the overall strategy, I think that needs to be worked out in terms of the requirements and needs. For example, the research councils, as I pointed out, have a major interest in the research programme that they are doing and the missions they are addressing. Departments will have different policies, and statutory needs.

Lord Taylor of Blackburn

202. If I may come in, what do you mean by "departments"?

(*Dr Wingfield*) Government departments.

(*Professor Flavell*) I want to emphasise also the international aspect of this. Of course we need to have a secure, understood national position to know what we are doing and why. But obviously biology is dealing with organisms of the globe and I think it is very important in order to get the best benefit out of the investment we are making to be able to link efficiently and harmoniously with what work is being done elsewhere around the world. I think therefore that the questions that you ask of our national position need to be extended to the inter-national

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[Lord Taylor of Blackburn *contd.*]

position. I think we get into concerns about the quality and efficiency of data bases that can talk to each other internationally, and I think we probably want to say more about that later on. When one considers the international dimension, then of course one might expect other countries or international institutions to be contributing to costs. However, perhaps in the academic area we share and exchange data on a free basis. Industry on the other hand is becoming increasingly involved in the need to recognise organisms either for the commercial identification of valuable intellectual property, or for detection of pathogens in food and crops. To the extent that they require material and know-how from the sort of data bases and collections, then it may be appropriate to ask whether industry should be encouraged either to play some role in supporting the collections and associated data bases or at least to make payments for information that they request.

Chairman

203. Do you make charges at present?

(Professor Flavell) Very small amounts.

(Dr Wingfield) The question you ask is a pertinent one. Industry benefits quite greatly, from the national collections that we have, and many of them certainly within the AFRC, based as they are on the research programmes we are running. Therefore, in a way we are actually giving quite a large subsidy to industry. On presently changing policy does not therefore cover the full costs, because, as I said, we are already paid in a way for the research we are doing. It needs to be addressed in some rather systematic way. I do not think it is just for one council to make the policy.

Lord Adrian

204. You have spoken of the value of maintaining the collections. This is a perfectly acceptable, straightforward idea. I think in your case the collections you are maintaining you would essentially justify because they are involved with active and on-going innovative research. I think there was the implication that there are some collections which perhaps are not engaged with or paralleled by active research. One can see that in some instances they may not be as active as the research going on into bacteria or viruses. Whose responsibility do you think it should be to maintain those collections which still have a value as collections but which may not justify your attention because you could not say they had a lot of on-going research with them?

(Professor Blundell) Maybe I could begin to answer that. My colleagues may want to contribute. I think it is clear that our approach is to address the problem of collections which are immediately adjacent to our own research activities. But we are aware that the progress of science is unpredictable and it is true that on occasions we do need data bases and collections of organisms which were not previously immediately relevant to agriculture or food. This is obviously going to be very important for pathogens, which may derive from many types of organisms. Perhaps the greatest importance of data bases and collections comes in the area of

biodiversity. Could I ask Professor Krebs to comment on this? Then we will come back to the question of who funds it—I have not forgotten that.

(Professor Krebs) Thank you, Professor Blundell. There are perhaps two points I would make here. The first has already been alluded to and perhaps I could go back over it: the relationship between different kinds of data bases. It is clear from what you have seen of our written response that AFRC's collections are of strains within one species or of a particular species of agricultural or disease significance. It would be important in thinking about how this kind of collection relates to the broader collections across a wide phyletic range such as you find in the museum is, ensure mutual compatibility of computerised data bases developed to handle these different kinds of collections. So whatever techniques the AFRC develops for maintaining computer data bases of its own collections should somehow relate to the collections of the museum on a broad phyletic scale. Secondly, with regard to the value of museum collections in the research field and how they relate to active on-going research, as opposed to simply sitting in drawers.

205. I was also assuming that they had a wider value besides just a research value.

(Professor Krebs) Perhaps I can address the research value first. I think clearly they have significance in relation to the very topical question of biodiversity: understanding not only the nature of bio-diversity but the causes, the factors that maintain diversity. In the agricultural context, one interest is in the relationship between diversity of native flora and fauna and agricultural practice, but of course the question of biodiversity extends far beyond that. Collections also clearly have an educational role which extends beyond the immediate value of scientific research. For example, in some universities in Britain, education in biological science is closely tied to the university's collections. I think that is true in Oxford and Cambridge, although some other universities are not necessarily as well placed or as fortunate.

(Professor Blundell) The question of who should fund it is I think not really the central question. We think that the funding should be co-ordinated centrally but we believe that most of the collections and the studies should be institutionalised; in other words they should be close to the research base. Much of the research of the rather basic type, for example invertebrates which do not have any particular application in agriculture or elsewhere, is going to be done in universities I would certainly see the Department of Education and Science through the UFC and of course the ABRC through the SERC biology committee having a role in funding this kind of research. It is our view that the broad pervasiveness of this kind of research affects environment, medicine agriculture and food as much as the very basic and perhaps non-strategic areas. It goes right across the government departments. It is important this responsibility should lie with some body, perhaps not necessarily a funding body, but one which is managing and co-ordinating, so that we can be sure that all areas are funded. We do feel a little insecure about the funding of our own

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[Lord Adrian *contd.*]

collections at the moment. They have had a long history. Half of our own collections are funded by the Ministry of Agriculture. We would like to see some longer term security of the funding, and I think that has to be looked at centrally. I would have thought the Department of Education and Science certainly should have a role.

(*Professor Flavell*) I would like to make comments about how things are handled in other countries. I think the scientific community and probably industry as well has greatly enjoyed interacting with collections which are maintained in the United States by long term support from NIH or NSF, and by "support" I mean not just the maintenance of organisms but the back-up of the staff to interact worldwide with anybody who is in the kind of work associated with those bio-materials. That is a national example where one funding body has taken the lead. The other one I wanted to draw your attention to is an FAO-sponsored international project on plant genetic resources where money is set aside out of the FAO budget to support the maintenance and use of plant collections. The resources that they have are nowhere near adequate to enable them to help substantially our plant collections in the United Kingdom. But, clearly they are a body that if by international negotiation could be better endowed would be the sort of international base that would contribute to the long term stability of collections on a fair basis.

Lord Whaddon

206. Professor Blundell, you do appear to be at the cutting edge of systematic biology. Before 1987 the Department of Education and Science was directly in charge of the Natural History Museum and at that time the responsibility was transferred. Have you noticed any difference in the quality of service, in the utility, of the Natural History Museum to yourselves before and after that date?

(*Professor Blundell*) I cannot answer from personal experience. I have had too little interaction directly with the Natural History Museum. We do fund research grants but our interactions are not very extensive, so we do not have a sufficient sample to answer. However, maybe Dr Wingfield could add something?

(*Dr Wingfield*) As far as we know, the agreement that was made with the transfer from DES to OAL has been honoured, inasmuch as the NHM is allowed to bid to research councils for grants. The AFRC at the moment funds one grant with the NHM and we have accepted other proposals for consideration. So in that respect there is still interest from within the NHM in securing outside research funding. There is still interaction with some of our institutions, and as far as I am aware we have not heard of any reduction in the level of interactions going on. I think there is some concern about the level of funding which is going into the Natural History Museum and perhaps its future, but at the moment I would say we have not got any strong evidence to say there is any change, one way or the other. Do you want to add anything?

(*Professor Krebs*) Just to confirm what Dr Wingfield said. I do not think, from my own personal experience, one has evidence yet of a decline in the

standard of service offered us. But these things take a very long time to change. There is a lot of inertia in the system and it may be that the perceived cuts in funding for taxonomy would have a long lead time before they have any serious effect.

207. If they were to deteriorate, it would be of great importance to you?

(*Professor Krebs*) I think it would be of great importance to the biological community as a whole.

Lord Porter of Luddenham

208. Can I put a question which I am sure you will not want to answer! Given that the systematic biology research is important, and given the funds will always be limited, where would you put your money, if you had any extra money, for extending systematic biology research? Would you put it for research in the Natural History Museum—let us leave out your own institutions—universities, research councils, institutions? Or to put it another way, if you were starting from here, would you start a research institution at the Natural History Museum? It is unique because of its connection with these wonderful collections.

(*Professor Blundell*) I think there are two aspects to where we would like to put money. First, as I said before, we see the importance of security and some identified responsibility for collections broadly. We would not envisage increased funding for taxonomy *per se*, we would pursue taxonomy as we are already, by making contributions driven by our broader objectives in Science. My own experience is mainly with the molecular data bases for DNA and proteins, I have been involved in developing such data bases. The major problem comes in getting the full value out of the collections. That means that if you have a collection of, say, wheat, or more generally of DNA sequences, then the value is not just in the collection but making it accessible and available to other scientific communities, and bringing it together with all of the data which is relevant to the biological system. My own view is that in the future, if there is more funding to go into the area of biological systematics, perhaps it has to go into the co-ordination and information technology level, bringing out the full value and making more accessible collections which we have. This has to involve the universities and all of the other institutions. I do not think we would want to give an answer that the extra money should go to one institution rather than another.

209. When you say "all the other institutions", you are including the NHM with them?

(*Professor Blundell*) I am including that. It is a very important component, but so are activities in the universities.

210. So you would split it between them? You think the funding at the moment, relatively speaking, of the NHM is about right? Relative to the other funding?

(*Professor Krebs*) If there were extra money for systematic biology, it should be available in a responsive way rather than directed towards a particular centre. I think that the Natural History Museum should compete on equal terms with

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[Continued]

[Lord Porter of Luddenham *contd.*]

universities or other institutions. Clearly there are some areas where the Natural History Museum would have a great advantage, but in other areas it may be better to do the research in another place. If I may say one more thing, this may come up again later on, but I did not want us to go away leaving the impression that we think the only two areas of significance in systematic biology are (a) molecular biology and (b) construction of large data bases. There are other cutting edge areas of systematic biology. Suppose, for example, you have done a lot of molecular biology attempting to elucidate the relationship between species or larger taxonomic groups, how do you interpret the data? If you think about it, there are some difficult problems of how you interpret genetic similarity. Supposing you know that 10 per cent of the base pairs differ between two species, you have to have in your mind some kind of model about whether the mutational changes are reversible or not; you must have some kind of model about the rate at which these changes take place, in order to use that information to construct phylogenies. So I think there are important areas of systematic biology to do with devising the statistics and other mathematical tools for interpreting data bases at molecular and other levels. This is a very active area of research in which AFRC is not involved, but one might want to encourage it if one had more money.

Earl of Selborne

211. I wanted to refer in particular to the plant sciences. It is clear the AFRC does not see its role within taxonomy through the traditional approach but, as we have heard already, very much more in the newer sciences, particular molecular biology, which is complementary to the traditional taxonomy; but equally there are large national collections such as the Royal Botanic Gardens, Edinburgh, Kew and the like which perhaps do have a role which is a valuable role in the more traditional taxonomic area and which have to be complemented if the sort of work Professor Krebs was referring to in biodiversity is to be pursued. Does it seem that the AFRC might be able to bring into the partnership, if there is to be one, with these botanic gardens these very new sciences that the AFRC is strong in? Is this an area you see developing within the plant sciences? Does John Innes see a collaborative role with the botanic gardens or others?

(*Professor Flavell*) I certainly agree with you that there is every reason from a fundamental science and intellectual point of view to understand the organisms which are on the planet and how they arose relative to one another and the differences between them. I think there is ample reason to put investment to generate that understanding. I also think that there is lot of pleasure to be gained from understanding the basis of organisms one sees in the botanic gardens around the world. I do not think the AFRC sees its primary remit in elaborating the work of botanic gardens, but it is the case that in this country the AFRC Institutes and the HEIs, have taken the lead in generating cutting edge science that has a role to play in furthering the sorts of questions that have been asked traditionally in the botanic

gardens. We would expect them to look to the AFRC science base in order to further their activities. I have had many conversations with colleagues in botanic gardens about such work and I know that some initiatives have taken place. So I think, yes, we would do it by personal contacts and perhaps some training but perhaps we would not make a major investment of AFRC funds.

(*Professor Blundell*) Could I add to that because there are two formal mechanisms whereby we do keep quite close connections with Kew Gardens and also with the Scottish gardens. One is through the Priorities Board of the Ministry of Agriculture, Fisheries and Food, where we consider the science at Kew in one of the sectoral groups. Thus, Kew is looked on as a component of the broader picture of research. You may know that the Priorities Board reports to the Chairman of the Agricultural and Food Research Council as well as the Secretary of State. The second aspect concerns the reviews of the science of Kew, for example, that are carried out with quite a large contribution of AFRC scientists. Indeed, the last review was chaired by one of our council members. So there is quite a good connection and quite a lot of to-ing and fro-ing concerning new techniques and new ways of approaching it.

Chairman

212. All your evidence suggests to me—this is a purely personal opinion—that you see that there are three elements which must always be together in systematic biology in future: namely, the old methods, if you like, the classificatory methods—after all, you must be able to identify plant, animal or microbe; the genetic relationships, using modern molecular biology techniques; and thirdly this information which is so complex but is also a type which lends itself very naturally to storage in computer based systems which will increase the accessibility of it. Now, this looks like a splendid future for this particular subject and yet we have a great deal of concern expressed on all parts, including yourselves, about the future of systematic biology research in this country, perhaps derived from the fact that so many people have a finger in the pie because it seems, to use your word, pervasive. Part of it also which we have not touched on—and I would certainly like some evidence from you about it—is the esteem in which systematic biology is held within the universities. This brings us to the point of asking if the young people are coming forward. It was a very unpopular subject. It ought, in view of what you have said about it, to become very popular again. There ought to be some training in it which brings all the three elements together. Would you like to comment on this aspect?

(*Professor Blundell*) May I begin by saying I think your summary of the three components is absolutely right. The diversity of the funding and its co-ordination is the problem. My own view is that there is a lot of taxonomy in research programmes involving young people. We are getting contributions from people who would not necessarily call themselves taxonomists. I always give the example of my own background in this respect. I was involved in working on insulin with Dorothy Hodgkin in Oxford

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[Continued]

[Chairman *contd.*]

around 1970. For the next ten years I was interested in unusual insulins and in collaboration with others we sequenced some insulins from relatives of the guinea pig. These are hystricomorphs. They have a funny horizontal way of masticating, like *that* (*indicating*), rather than as most animals do. They had been classified anatomically. We noted that the insulins were very fast changing in this small subgroup of rodents. The sequencing in the 1970s of about ten or more of these different hystricomorphs gave a new phylogenetic relationship which in fact contradicted the classical one. I maintain that that kind of effect is occurring again and again in the universities and in the institutes. That is where a lot of the taxonomy is actually occurring. That kind of work is held in extremely high esteem. What is less esteemed is the rather more anatomical approach of classifying the organisms using more traditional techniques.

(*Professor Krebs*) I will comment from my own personal experience of teaching under-graduates at Oxford. The first thing I would say is that we do not have any hard data about this perception that young people are not interested in taxonomy, it is just an impression one has.

213. But you do have options at Oxford which also enable you to find out?

(*Professor Krebs*) Oxford is probably unusual in its biology degree in that basic taxonomy, classification of plants and animals, is a compulsory part of the course, so our students have to do it. I think it is a good feature that students are still taught basic taxonomy of plants and animals. It is not true in many other universities in Britain. One can see the contrasts between Britain and the United States in this regard. In many of the famous North American universities—Yale, Harvard, University of Michigan—there is a close relationship between university museums and under-graduate courses. This is true in Oxford and Cambridge, but not in many other universities in Britain. Similarly one sees big biology departments in North America having on their staff people who teach courses such as mammalogy, herpetology or ichthyology. One does not see that in Britain. Indeed the appointment of university staff who are specialists in a particular taxonomic group are rare in Britain. I would point to that as concrete evidence that there is a decline in the esteem of taxonomy.

Lord Adrian] There are two forms of compulsion. One is where they do it because they are told to do it, and the other is because it is so exciting they want to do it. Which do you have at Oxford?

Chairman

214. One is compulsion, the other is impulsion!

(*Professor Krebs*) The things the under-graduates find intellectually exciting in taxonomy include the use of novel molecular techniques to reconstruct phylogenies. Our perception of how major events of evolution took place is changing as a result of molecular biology. At the other extreme, students perceive as very exciting the subject of micro-evolutionary events, the differentiation of populations on small scale. What are the forces which drive differentiation? Is it natural selection?

What are the consequences of differentiation in terms of evolutionary change or stability of populations? There is intellectual excitement in many areas which relate to systematic biology, although being forced to learn about the jaw muscles of the hystricomorph rodents may be for many people compulsion rather than inclusion!

Lord Adrian

215. Can I follow up this theme of the perception of taxonomy? I think in your opening remarks you said that none of the four of you admit to being taxonomists, I wondered whether that was merely that you were not taxonomists or that you would not admit to being taxonomists!

(*Professor Blundell*) In almost every research area that I have contributed, I think I have made a contribution in taxonomy, but it was not the reason I did the research. I did the insulin research because I was interested in how insulin interacted with its receptor and its relationship to diabetes, and similarly in other areas. All over my office in my research laboratory there have always been phylogenetic trees. Mainly they came from the molecular studies, but they led to interest in whole organisms in the way I have just described. I really think this is a very healthy aspect of taxonomic research and it is really going on in all places. Professor Flavell you have done a lot, have you not?

(*Professor Flavell*) Yes, that is a fair description of my personal history too. If one is looking to the future, there has to be a coming together of the old and the new through the natural expansion of cutting edge science. While there is still obviously considerable interest in single molecules, the frontiers of research are now moving towards the molecular bases of development and the development of the very structures that taxonomists have used to define organisms. Genetic variants are being created artificially to change the shape or position of those structures that taxonomists have used. I think as this developmental biology opens up, there will be many developmental biologists who will find themselves addressing the very material that taxonomists have been addressing, and so systematic research of this kind will continue to flourish. But, I still have a suspicion it will be a long time before developmental biologists or molecular biologists will readily admit to being systematics biologists, for reasons that are perhaps obvious and will remain.

Chairman

216. You have been very up-beat about all this in the last few minutes, but perhaps you can help us now because a number of people have said the state of affairs is not really a very good one in this country at the present time in many ways. You yourself have said you think there should be a review for a variety of reasons and you have mentioned specifically, and I would like you to answer on this, that the Cabinet Office should be involved, although NERC is doing its own review. There was an enormous uproar of an international kind when the Natural History Museum's corporate plan was announced with the changes which were implied there, all of which tends to suggest the state of affairs is not particularly good.

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[Continued]

[Chairman *contd.*]

You yourselves feel a review is necessary. Who do you think should conduct it? Where should the ultimate responsibility lie? Is it with ABRC as responsible for the science itself or with the DES itself? Why the Cabinet Office?

(*Professor Blundell*) Clearly any review has to be –

217. Is it necessary first?

(*Professor Blundell*) I think a review of the United Kingdom contribution to taxonomy is important, because taxonomy is done in such a fragmented way and for different reasons. If we are going to have the value from work on individual projects, we have to be sure the information which is relevant to taxonomy is made available to the broader scientific community, and so all of the various kinds of data bases have to be accessible. That is the point I made before and it is related to information technology and computerised systems. So I think a review is important. I personally do not have very strong views as to who should do it, but I think it should be one of the bodies which over-arches science, and it must include the research councils and the departments of government and the universities. I think that is perhaps why we came towards the Cabinet Office, which after all does have a biologist at the moment as its chief scientist. I would have thought, with its input into the relevant bodies, it could have an over-view. But the ABRC is increasingly looking at cross-departmental questions as well as cross-council ones, and there is a biology sub-committee which has just been formed by the ABRC which could co-ordinate the work. However, I still would favour the Cabinet Office in that it has more direct connections to all those who should be consulted.

218. Do you think the transfer of funds which is proposed should take place from the Universities Funding Council to the ABRC, will increase the capacity of universities to enter the exciting areas of development in the way you suggest?

(*Professor Blundell*) I think this is a complex question because in my view one of the major values of the transfer of funds is the identification of the proper level of support which is required for university funding. This has not been properly identified in the past and there is a problem that there is probably not enough money in the system. If we can identify the different components that should be there, then it must be beneficial. For any project supported by a research council, the transfer of funding will mean that we have identified those full costs which are required to carry out the project.

219. May I interrupt you at that point? You said a moment ago the transfer would help you to identify and just now you said that the transfer of funds is “because we have identified”. Where do you stand on this.

(*Professor Blundell*) It is a complex issue.

220. Evidently, if you can give two contradictory remarks like that.

(*Professor Blundell*) I do not think the remarks are contradictory at all. I think the problem has been that we have had a system that assumed that there was a contribution in the dual support system and that had not been identified at the level of the individual and his or her programme. In other words, we were not

sure that there was sufficient dual support funding paralleling the sum of money that we gave as a research council. What we have just done has been to identify the extent of that support which is required in the sense that we have just given advice as a result of a review carried out by the research councils of what that level of expenditure should be. So we have identified the extent. We now have to make sure that the funds fully costed go to the individual who is carrying out the research. There are several levels of identification. I do not think there is a contradiction.

221. Is the method satisfactory? This is a very broad question, but an essential one, is it not?

(*Professor Blundell*) You mean, are the new proposals –

222. I was asking whether you are satisfied with the method of identification of the amount of money given by universities to research projects?

(*Professor Blundell*) We have carried out an extremely detailed study in which I and all the other heads of research councils and our staff have been involved. We have taken a sample of the universities and polytechnics, we have taken a sample of the different research activities, and we have evaluated whether those samples are statistically meaningful and where the weaknesses might be. We have then used them to get a figure of the support funds required for the funding component that we have traditionally given. I think it has been done extremely carefully and it is of great value.

Lord Adrian

223. I am quite sure it has been done extremely carefully. I would like to know whether the universities have seen the figures and agreed with them?

(*Professor Blundell*) The report that has been produced is a joint one between the heads of research councils and the Committee of Vice-Chancellors. There is a small difference in the figure which we have come to. This probably depends on how one weights medical and other departments, but I am pleased to say there is a great deal of unity in the conclusions.

Chairman

224. Does that leave the universities with sufficient free resources still to be able to give support to the young researcher who is not yet in a state of having applied successfully to the research council?

(*Professor Blundell*) I can give a personal answer to this, which may not be the view of the AFRC in general. Because over the past years we have not identified within the dual support system exactly where the funds for research support of projects have gone, we cannot be absolutely sure that there is enough money in the system to fund all of the activities which the universities are supposed to be supporting. Therefore, if we remove the total funding required to support the research council component, I cannot be sure that there is enough money left in the system. For example, we need to study further the training support for research students funded by our research councils. We must ask whether there is sufficient recurrent funding to support their research

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[Continued

[Chairman *contd.*]

projects. For example, £5,000 to £8,000 a year for each project would be my estimate of the need.

225. Does that particularly bear on equipment or services?

(*Professor Blundell*) That statement was mainly about services and recurrent funding. Funds for equipment, as you know, have always been identified separately within the university system and, therefore, have been more protected. But recurrent funding has never been identified centrally and so we are really not sure in our university system what is happening to it.

(*Professor Krebs*) If I could follow that *a propos* taxonomy, as to Professor Blundell's last comment about whether there is sufficient funding in the dual support system for research students, one might say the same about taxonomy to the extent that those who would profess to be professional taxonomists, particularly of the traditional kind, do not, I suspect, most of them hold research council grants and are getting their research support through the dual support system. To the extent that the new regime will erode the dual support system, it may well harm that kind of taxonomic research. I do not know if that was the point of your question.

These are people who have little in the way of resources, it is easy to squeeze them for that reason. May I give you now the opportunity to make any points which we have failed to touch on which you think we should know about? Of course, it is always possible for you, if as a result of this giving of evidence you have second thoughts, to submit further written evidence if you wish.

(*Professor Blundell*) We have certainly had a good opportunity.

(*Professor Flavell*) I did want to pick up on the point, which I think was a very important one, that

you mentioned towards the end when you said to us that we had seemed upbeat in the last few minutes and many others were feeling very moribund about the subject. I have a view as to why that is. I would say that in the last ten or fifteen years in which there has been a heyday of molecular biology it is probably fair to say that there has been much less regard for the whole organism. Systematic biologists of the traditional kind are very much concerned with the whole organism. So, if this is the basis of why they feel the subject is at a low ebb, I can agree with them and see why. We should also note that AFRC scientists who, for example, are involved in plant or animal breeding are very aware of the whole organism and the necessity to understand the way that genetic variation influences the whole organism. I believe, as I was indicating before, that as developmental biology progresses there will be a swing back to a concern to understand the whole organism. For that reason, amongst many others that are well elaborated by conservationists, I think it is very important that the studies on the whole organism are kept alive. Also because cutting edge science will continue to need such studies, there will be a swing back even more. So I share the concern of the classical systematic biologists and hope that anybody commenting upon the national or international status of research will take care of the whole organism and its genetic base, because they will be important to AFRC and many others when future research increasingly addresses whole organism behaviour from a molecular point of view.

(*Professor Krebs*) I fully endorse that.

Chairman] Thank you very much indeed for coming. We have much enjoyed it.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 30 April 1991

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Dr D W F Shannon, Dr B J Shreeve and Dr A R Hardy

THE SCOTTISH OFFICE

Dr T Hegarty, Mr K W Moore and Dr D Ingram

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Present:

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Cranbrook E.	Selborne E.
Dainton L. (Chairman)	Walton of Detchant L.
Flowers L.	Whaddon L.
Nicol B.	

Memorandum submitted by the Ministry of Agriculture, Fisheries and Food (MAFF)**SUMMARY**

Systematic biology, which covers the identification, naming (taxonomy) and classification of organisms provides the foundation for biological investigations.

MAFF funds a substantial body of work on systematic biology, primarily to enable it to fulfil its statutory responsibilities and thus protect the health of the nation, but also to enable Ministers to develop policy. MAFF has a special responsibility, as sponsor Department, for the world-renowned centre of excellence for systematic biology at RBG Kew which it funds with a grant-in-aid. The work carried out at Kew has benefits worldwide. MAFF funds some systematic biology on behalf of others, such as the work at CAB International (formerly the Commonwealth Agricultural Bureau).

MAFF is currently taking the lead in developing a more coherent policy on the conservation of plant genetic resources *ex situ*, within the UK and internationally.

Systematic biology is a necessary part of the country's science base and MAFF will continue to play its part in funding R&D in this area to ensure its vigour and utility. MAFF will continue to fund its own work and work in collaboration with scientists at other centres of excellence.

1. INTRODUCTION

1.1 'Systematic biology' includes the identification, naming (taxonomy) and classification of organisms.

1.2 Systematic biology provides the foundation for biological investigations. It uses a wide variety of scientific and technical methods. Systematic biology not only leads to the classification of organisms, it also underpins ecological and evolutionary studies for example and has many practical applications such as combatting pests and diseases. It is a necessary part of the scientific activity of the country and MAFF has a major role in sustaining it.

1.3 In submitting this memorandum, MAFF is aware that other organisations and Departments with which it has close working relationships will be submitting evidence to the Committee. These include the Scottish Office Agriculture and Fisheries Department (SOAFD), the Agricultural and Food Research Council (AFRC), the Royal Botanic Gardens (RBG) (Kew) and CAB International (CABI).

2. MAFF'S UTILISATION OF SYSTEMATIC BIOLOGY

2.1 MAFF utilises systematic biology in support of work relating to its statutory responsibilities and its commitment to Research and Development in a number of areas for which it bears responsibility.

(a) Identification of Pests, Disease Organisms and Weeds

2.2 The protection of the United Kingdom from pests and diseases, both imported and domestic, is a major function of the Ministry. Invertebrates, fungi, bacteria, viruses and plants which must not be imported into the UK are named in Plant Health Import legislation. It is necessary for the implementation of these laws to identify these organisms. Systematic biology enables this to be done. Considerable financial losses could result from erroneous naming of organisms by MAFF scientists. Also, the Weeds Act, which requires that certain named weed species should not be permitted to grow in the UK, relies on the accurate identification of weeds.

2.3 Accurate identification of organisms is also needed for MAFF to meet its commitments under European Community (EC) legislation and International Plant Health requirements. Inaccurate detection and identification of organisms may have severe consequences for the UK's export trade, and alien pests (eg Colorado potato beetle, South American leaf miner) and diseases (eg Rhizomania) might threaten the UK agricultural and horticultural industries.

2.4 Pesticides Use Regulations define species of organisms against which individual pesticides are permitted to be used, the crop species on which pesticide use is permitted, or both. Again, it is necessary to identify the organisms in order to enforce these provisions.

*30 April 1991]**[Continued]**(b) Dealing with Diseases of Animals*

2.5 Systematic microbiology (especially the systematics of bacteria and viruses) is particularly important to MAFF in the fields of Animal Health and Welfare and Veterinary Medicine. It serves a wide variety of functions: it aids in the identification of new and emerging diseases of animals; it defines zoonotics by establishing exactly the species or subspecies etc of organism which is involved; it facilitates studies of epidemics by, for example, finger-printing individual strains following typing at the species and sub-species level; it aids in disease control by helping in the production of diagnostic kits and vaccines; and it facilitates studies on pathogenesis by defining virulence determinants. Studies in systematic biology may benefit the investigation of diseases that may be transmitted from animals to man in this context, studies on the systematics of vectors of diseases are particularly relevant.

2.6 The application of basic studies in systematic biology which provides the ability to identify causative agents of diseases in animals is relevant to MAFF's responsibility as Licensing Authority of veterinary immunological products.

(c) Applying Intellectual Property Rights

2.7 Systematic biology provides the means of specifying organisms in relation to Intellectual Property Right (IPR) in the field of biology-based innovation. Up-to-date techniques enable organisms to be identified, for example for patent descriptions relating to diagnostic kits and vaccines.

2.8 For microbiological and biotechnological patents, the deposition of precisely characterised organisms is necessary under the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure 1977. This requires MAFF scientists to apply up-to-date methodology and nomenclature.

(d) Fisheries Systematics

2.9 Systematics are also used by MAFF fisheries scientists involved with the epidemiology of disease-causing organisms in fish. Here interest centres on viruses (down to serotype), bacteria (particularly those associated with fish and shellfish diseases) and, to a lesser extent, fungi (for example in relation to crayfish plague). The application of systematic biology is also important in the study of toxin-producing unicellular algae (eg those that cause Paralytic Shellfish Poisoning).

(e) Plant Breeding

2.10 Systematic biology, which enables the accurate identification of, and thus discrimination between, plant genotypes performs a vital function in MAFF's statutory role in carrying out Plant Breeders Rights legislation through the Plant Variety Rights Office. This work enables new crop cultivars to be characterised, included in the UK National List and subsequently made available for sale in the UK and other parts of the EC.

(f) Plant Genetics Conservation

2.11 MAFF has a significant interest in the ex-situ conservation of plant genetic resources and currently funds the Vegetable Gene Bank, the National Fruit Collection and the Pea Gene Bank. Indirectly, it also funds the gene bank of Wild Species at RBG(Kew). The funding of the gene banks is designed to help ensure that genetic resources are available for research (eg screening for resistance to diseases) and as material for the development of new crop varieties (eg to meet new pests and diseases, changes in demand and climate). The funding also serves to maintain a part of the UK's agricultural heritage and to meet certain international obligations. Thus the Vegetable and Wild Species gene banks are designated as base collections under the International Board for Plant Genetic Resources. MAFF is also leading for the UK in international discussions aimed at co-ordinating the international effort devoted to the conservation of plant genetic resources and to research upon the collections. An important component of all this work systematics play an important role.

(g) Biotechnology

2.12 An accurate understanding of the systematic biology of genetically modified organisms (GMOs) is fundamental to MAFF's requirement to be able to assess the risks of releasing GMOs, for example by sowing a modified field crop. Such an understanding can only be based on accurate identification of the organisms involved. Some detail of the level of understanding required is provided by EC directives 90/219 and 90/220 on the contained use and deliberate release of GMOs and by the consequent regulations to be made in the UK under the Environmental Protection Act 1990.

2.13 MAFF's needs for systematic biology in a supporting role are many and diverse, as preceding paragraphs relating to some of the Department's statutory and non-statutory responsibilities illustrate. However, the Ministry's requirements go wider and lead to a considerable amount of support for R&D in this

*30 April 1991]**[Continued]*

area of science. The fundamental reason is that MAFF scientists involved in a wide range of biological R&D rely on the accurate characterisation of the organisms with which they work but, also, some of the basic science contributes to the UK science base and to the world's knowledge of the animal and plant kingdoms.

3. MAFF SUPPORT FOR COLLECTIONS USED IN SYSTEMATIC BIOLOGY RESEARCH

3.1 Reference collections of organisms, especially those of original "type" specimens, are vital to systematic biology: they provide the biological material with which samples for identification can be compared.

RBG (Kew) Collections

3.2 MAFF's major support for systematic plant biology research is the grant-in-aid which it provides for RBG(Kew), this grant covering some 85 per cent of the Gardens' expenditure. A significant component of this expenditure relates to the collections. The legal basis for the public funding of RBG is the National Heritage Act (NHA) 1983, through which the Gardens were transferred from MAFF and become a corporate body under a Board of Trustees, with effect from April 1984. RBG's programme of research is determined by this Board and RBG's Director, in consultation with representatives of appropriate outside bodies.

3.3 RBG's obligations under the NHA include a commitment to maintain plant collections as a national reference collection. Through the 1969 Morton agreement, which divided responsibilities between RBG(Kew) and the Natural History Museum (NHM), NHM focuses on flowering plants from Europe, the Mediterranean Basin, North America and the West Indies; RBG's remit covers the rest of the world.

3.4 RBG(Kew) has other responsibilities, shared with NHM, for other members of the plant kingdom. Thus responsibility for ferns lies with RBG and for bryophytes and algae with NHM. RBG's mycological responsibilities are shared with the International Mycological Institute (IMI) of CABI (see paragraph 3.5). Thus, through the original agreement, IMI focuses on microfungi (and in particular pathogens) whilst RBG is required to concentrate on larger fungi.

CABI Collections

3.5 MAFF is also the lead UK Department in relation to CABI, an inter-governmental organisation which provides scientific and development services on agriculture and related disciplines throughout the world. Within CABI are three bio-systematics institutes: the International Institutes of Entomology (IIE), Parasitology (IIP) and Mycology (IMI). Benefits of CABI membership include free access to the identification services provided by the bio-systematics institutes.

MAFF Collections

3.6 Some of MAFF's science laboratories have their own reference collections, used by not only MAFF scientists but also by those from other UK institutes (eg CABI, NHM and those within the control of the Agricultural and Food Research Council (AFRC)). Thus CSL (Slough) has a collection of invertebrates known to cause economic losses of stored products, CSL (Harpenden) maintain the National Collection of Plant Pathogenic Bacteria and, on a more restricted level, MAFF's Fisheries Laboratory at Weymouth maintains a collection of pathogens of fish.

3.7 In addition, there are several International Reference Laboratories which MAFF maintains. At the Central Veterinary Laboratory (CVL), these include the Office Internationale des Epizooties Reference Centre for Newcastle Diseases, the Food and Agriculture Organisation (FAO) of the United Nations Reference Laboratory for Newcastle Disease and avian influenza, the FAO/World Health Organisation (WHO) Collaborating Centre for Reference and Research on Brucellosis and the WHO Collaborative Rabies Research Laboratory. CVL is also an EC-recognised National Diagnostic Laboratory for swine fever, enzootic bovine leucosis, Teschen disease, Aujeszky's disease, equine encephalomyelitis and equine infectious anaemia. The Pirbright Laboratory of the Institute for Animal Health is substantially funded by MAFF and has a prominent role, similar to that of CVL, in relation to Foot and Mouth Disease and other exotic diseases.

3.8 Although the National Collection of Industrial and Marine Bacteria, Aberdeen (once funded by MAFF) has now been taken over by Aberdeen University, the Collection does still receive some support from MAFF's Fisheries budget. Collections of higher organisms (eg. rainbow trout) maintained previously by MAFF proved prohibitively expensive.

3.9 These extensive supported Collections demonstrate that MAFF is committed to contribute to the overall responsibility for collections of organisms included in the UK's National Heritage and has a policy need to do so. This reflects the Department's belief that systematic biology is an essential element of the science base and provides the necessary expertise and knowledge needed to support its statutory and R&D work. MAFF seeks to ensure that a capability to meet its needs for routine identification work is maintained.

3.10 The Department recognises that, in some cases where other expertise may be required, collaboration will be needed with experts in other organisations. Significant among these experts are those at NHM (for

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insects and animal helminths), CABI (for microfungi and plant parasitic nematodes), AFRC and ex-AFRC institutes (for viruses) and certain University Schools of Hygiene and Tropical Medicine (for animal helminths). Similarly, MAFF expertise is available to other organisations where it is required. Such collaboration is essential.

4. NEW DEVELOPMENTS IN SYSTEMATIC BIOLOGY

4.1 Like all scientific disciplines, systematic biology is developing all the time. New areas of activity may provide additional assistance to MAFF's responsibilities. MAFF is committed to fund R&D in this area to ensure continued scientific vitality.

4.2 Morphological techniques, as well as the more recently developed methodology associated with cytotaxonomy, numerical taxonomy, behavioural taxonomy, immunotaxonomy and host-parasite relationships, remain useful in systematic biology research. In addition, molecular techniques offer exciting new opportunities in some instances, not only in systematics *per se* but also in the exploitation of plant genetic resources and the maintenance of biodiversity. Up-to-date methods of data-processing provide another good example of the way in which new technology can be applied usefully in systematic biology.

4.3 The increasing complexity of many modern techniques used in systematic biology research and also of the technology needed to ensure the safe handling of samples (eg of disease-causing organisms) have important implications with regard to the cost of the work. Thus it becomes increasingly improbable that reference collections using these techniques, and their associated scientists, can be accommodated other than in specialised centres. At these, time-consuming and highly skilled curation must also be available. These demand increasing levels of resources.

4.4 In contrast, for problems of systematic biology not requiring up-to-date, sophisticated techniques for their solution, researchers may well be able to operate outside the main centres of specialisation. Aspects of the identification work done at MAFF's Central Science Laboratories exemplify the viability of the wholly in-house approach and of the need to collaborate closely with specialised centres (eg NHM).

FUTURE DIRECTIONS

4.5 MAFF will continue to seek to ensure that it has the resources needed to maintain its present approach to the use of systematic biology in support of its work. The application of systematic biology research to microbiological aspects of plant and veterinary science is likely to be of special significance in the Department's future work.

Examination of Witnesses

DR D W F SHANNON, Chief Scientist, Agriculture and Horticulture; DR B J SHREEVE, Deputy Director, Central Veterinary Laboratory; and DR A R HARDY, Deputy Director, Central Science Laboratory, Ministry of Agriculture, Fisheries and Food, called in and examined.

Chairman

226. Good morning, Dr Shannon and colleagues. I understand that you have some others with you besides just the three of you. Is that right?

(Dr Shannon) No, just three members of the team.

227. Thank you for your written evidence, describing all your activities, for which we are very grateful. We would like some of these activities to be quantified in financial terms, if you can. Perhaps it is unfair to ask you to do something today, but would you like to do so if we were to ask you separately in writing?

(Dr Shannon) I think we can give you some clarification of the financial side today.

228. That is splendid, in which case, that brings me to my next point. It would be helpful, if you were agreeable, to lead off and make a general statement which incorporated this.

(Dr Shannon) Can I first of all introduce my team? I have Dr Shreeve with me, who is the Deputy Director of our Central Veterinary Laboratory, and Dr Hardy, who is the Deputy Director of our Central Science Laboratory. The Central Science Laboratory deals with issues of plant health and also storage of pests. The role and functions of the Central

Veterinary Laboratory are well-known. What I would like to do, if I might, is just to first of all very briefly draw out four points from the written paper. Firstly, I hope the paper brings out the extent to which MAFF makes use of systematic biology. Perhaps this is not surprising, in view of MAFF's wide-ranging responsibilities, many of which involve interactions with the plant and animal kingdoms, and some of which are regulatory in nature. The use of systematic biology occurs in many guises, some of which are fairly basic and routine, but others which involve detailed DNA sequencing, etc. I hope the paper secondly also brings out the Ministry's significant and long-standing involvement in systematic biology through its responsibilities, in particular, for Royal Botanic Gardens, Kew, and its responsibilities on behalf of Government for making the contribution to CAB International. I think you are intending to see the Director of Kew and representatives of CABI, so I would be pleased to answer questions on MAFF's interrelationship with these bodies, but obviously more detailed questions on their programmes of work and so on would be better addressed to the individuals directly concerned when you see them. Thirdly, we have an involvement in the conservation of plant genetic resources, and this is an area where we are actively trying to develop

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[Continued]

[Chairman *contd.*]

a United Kingdom policy in conjunction with other departments, and indeed more widely in the Community and with FAO. Finally, on funding, MAFF will continue to seek to ensure that it has the resources needed to maintain its present approach to the use of systematic biology in support of its work and to meet its obligations to Kew and CABI. That is what I would like to say by way of introduction. Turning briefly to the question of MAFF's involvement in systematic biology itself, I think the definition of systematic biology and precisely how much effort and expense is involved depends a considerable amount on the definition, but broadly speaking, we would say that we have something like 40 years devoted to systematic biology and probably our expenditure is roughly £1.8 million. That I should say is expenditure within the Ministry rather than through our responsibilities for Kew and CABI.

229. When you say through the Ministry, you mean through your own labs and so on.

(*Dr Shannon*) About 20 staff years is deployed at the Central Science Lab and about 10 staff years in relation to Fisheries and Food responsibilities in Fisheries and Food laboratories, and something of the order of perhaps 10 staff years in relation to animal health. Again, it is very difficult in terms of definition whether you include gene sequencing and other aspects.

230. Are you saying that is 10 staff years in any one year? I do not understand how you are using it.

(*Dr Shannon*) Ten staff years of effort in any one year and every year. Our total effort devoted to systematic biology is about 40 staff years, and that 40 staff years is 40 staff years of effort each year.

231. So it is 40 men working every year.

(*Dr Shannon*) That is correct.

232. It could equally well be four men working for 10 years, could it not?

(*Dr Shannon*) Yes.

233. And a sum of money?

(*Dr Shannon*) Roughly speaking, £1.8 million.

234. That is clear. Thank you. Is there anything else you want to add to that?

(*Dr Shannon*) If you would like a fuller description of what the 20 man years are deployed on, Dr Hardy would certainly be able to tell you about the range of activities, and on animal health, Dr Shreeve.

235. One question which comes to me is this question which in a sense is hinted at in your paragraphs 2.3 and 2.4, and indeed, the whole of that section. The case is made that you have an enormous amount of work which you do which protects us against possible deleterious effects. The problem is to quantify what are the disasters you have protected us against, and the question would then be we are we adequately protected? Do we need more systematic work?

(*Dr Shannon*) I would ask Dr Hardy to comment on that from the plant point of view and Dr Shreeve from the veterinary point of view.

236. Could we get some sort of handle as to what might be the cost of a foot and mouth outbreak, for example?

(*Dr Hardy*) I think Dr Shreeve can help you with that one. In terms of the Central Science Laboratory, one of our spheres of activity and responsibility is the realm of plant health and support to the Plant Quarantine Regulations, and by implication, of course, systematic biology. Identification is absolutely crucial in that field, particularly in some of the more difficult areas of micro-organism identification, bacteria, fungi and viruses, where it is particularly important to get the right organism in order to define and develop the correct control procedures to prevent the problem in the United Kingdom. We are currently within the Central Science Laboratory putting in about 17 staff years of effort each year into that area. That effort will increase, because one of the implications coming upon us is the Single European Market in 1993, which of course will have implications for plant quarantine. At that stage there will be very much an increased need for increased support of the Plant Health Inspectorate and the policy divisions, and we are planning ahead to increase the resources into that area by some five, ten, fifteen man years over a two- or three-year period.

237. Why when you become unified is it necessary to increase the amount of protection? Is this because of freedom of movement?

(*Dr Hardy*) All the regulations are going to change. What will happen at that stage is that, at the level of a grower, in terms of individual Member States, each batch of plants, whether it is going for movement within a Member State or between Member States, will be accompanied by a plant passport. That whole process will require greater technical back-up to the enforcement side and also the identification and guarantee of plant health. So the whole thing will require more resources to operate it.

238. It also means, does it not, that there is a common European Community interest in this field, and that raises the question which we did put in one of our questions. Is there a case now for non-UK, European, international financing of some of the work?

(*Dr Hardy*) Perhaps Dr Shannon might like to pick that one up, but we certainly have a lot of contact with other European colleagues, particularly in the plant health field—in Germany and the Netherlands, for example, where we are faced with the same problems, including the same range of alien pests and diseases, and there is a lot of interlinking collaboration in terms of methodologies in systematic biology. So there is already a fair degree of interchange. I do not know whether Dr Shannon would like to say anything.

239. Could we pursue this further, because of course we are concerned to know whether the state of systematic biological research in this country is at the level at which it should be, and we therefore look with other countries of comparable size in Europe—and you must know a great deal about them. Is it your impression that we are in a satisfactory condition in our research to provide for the needs that you have spoken of as compared with, say, Germany or France?

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[Chairman *contd.*]

(*Dr Hardy*) From the contacts we have from our laboratory with other institutes in Europe, the sort of methodologies which are in place and the increasing use of the new bio-technologies coming in for systematic identification, we have sufficient resources in-house to deal with the problems that the Ministry is looking at. However, I have already suggested that we are going to need more resources to cope with what we anticipate as a greater work load in the next two or three years.

240. That is a splendid evasion of my question, which I admire.

(*Dr Hardy*) I apologise. It was not intended to be.

241. What I really wanted to know is whether the French or Germans, for example, are in a state in their biological research which enables them to do the job that they feel they have to do just as long as you have to do. Are you content therefore that the British research in this field is adequate for your purposes?

(*Dr Hardy*) My understanding from the contacts we have is that our colleagues in France and the Netherlands are in a satisfied state in terms of the resources they have, but that is an impression from a scientific point of view.

(*Dr Shannon*) Clearly, systematic biology is an international area of activity. I think the United Kingdom finds itself in a somewhat unique position because of its history and so on, with having perhaps a disproportionately large amount of material, and that brings obligations and to some extent difficulties. I do not think the sorts of problems that are being faced in the United Kingdom are significantly different from those that are being faced by other collectors and collections in the remainder of Europe. Clearly, there is a need for international integration, certainly on the plant genetic resources side. That is why we are active in that area. I would like to perhaps ask Dr Shreeve to say something about the veterinary side and the hazards that the veterinarians can store up for us.

Lord Flowers

242. Before we go on to that side, can I push it a bit further? We have asked about the comparison between our capabilities and those of France and Germany or the Netherlands, for example. What are the trends? We were in the front of much of this sort of work at one time.

(*Dr Shannon*) Yes.

243. Are we on a downward path now compared with the French and Germans, or are they upwards compared with us?

(*Dr Shannon*) I am not sufficiently aware of the total scene to give a very definitive answer on that. I think we are as advanced in terms of our plant genetic resources and our thinking in that area as many of our European neighbours are. Whilst traditional taxonomy has in the eyes of many people been in decline, the newer areas of molecular biology and molecular systematics have been expanding quite rapidly, and I suspect the United Kingdom is as well advanced in that area as are many of our European partners. I make those statements without any

definitive financial knowledge or knowledge of the inputs of staff resources.

Earl of Cranbrook

244. It is important we should try to get a grip on the answers of some of the questions of international comparisons and international co-operation. I wonder if Dr Shannon can advise us where we can seek this. Should he not perhaps also be interested in the answer to these comparisons?

(*Dr Shannon*) There is quite a lot of co-operation between the directors of the various establishments. The Director of Kew, for example, will have a very good knowledge of what is going on in the rest of Europe. We within the Department have tended to focus on the plant genetic resources area and to try to get some common policy on that area because, because of the problem of collections that are no longer adequately funded and the problem of duplicatory collections, it seems to be an ideal area where one would seek to co-operate with one's neighbours so that the resources were used to best effect, so that we did not duplicate unnecessarily a collection, and therefore had more money to invest on maintaining the collections we have and on research around the collections. The collections themselves are of relatively little value if you do not have good information on what they contain.

Chairman] This brings us to the key point as far as we are concerned arising out of what Dr Hardy said earlier, namely that if you are a country which has disproportionately large collections of international importance, if you want to bring in newer, important methods, within a fixed envelope of expenditure, this means your curation and work on the basic collections has to diminish in real terms. That is why, following on what Lord Cranbrook has said, we feel the international comparisons are not only useful but they could be a springboard for inviting other countries to recognise that we have a supranational job.

Earl of Cranbrook] Chairman, I wonder whether Dr Hardy would agree. I would question whether in comparison with the Dutch we do have a disproportionately large collection, and also the French have a very large international collection.

Lord Walton of Detchant

245. Can I follow up by asking in relation to evidence we have received in writing? We have been told about the work of the International Union of Biological Science and its Committee for Data in Science and Technology and about some organisations: International Database and Information Service and the Global Plant Species Information Service. They all sound splendid, but the question is to what extent are they effective, to what extent are they developing internationally agreed databases, and are you involved in this?

(*Dr Shannon*) We are involved in seeking to get a more rational approach to the maintenance of plant germ plasm in Europe. It is not an easy area, because many of the collections have been collected by individuals and have been made in relation to particular pieces of research, and in some respects are

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held in universities and other places and are inadequately funded. It is surprising, when we have tried to put this policy together for the United Kingdom, the number of collections that have literally come out of the woodwork. They have been under-funded, and the idea that someone might be taking an interest has suddenly brought them out into the open. I think it would be dangerous for us to have an all-embracing policy that was dictatorial in some senses, because many of these collections receive support from diverse sources, but what we would like to do would be to get some rationalisation of the key collections and the major collections, and then perhaps leave the others to their current owners and their own current funders.

Lord Porter of Luddenham

246. Dr Shannon, who would you feel would be the natural co-ordinating body? It would not be MAFF, would it? You say there are these collections all over the place. Some of them you are still discovering. Surely there has to be a central body if this is ever all going to be put together. It would not be MAFF, would it?

(*Dr Shannon*) We are trying to develop a policy within the United Kingdom. I suspect the natural home to execute the policy would either be the Cabinet Office, or perhaps the ABRC might be another possibility. Within the wider context, of course, FAO and the Community have interests.

Chairman

247. We must not neglect the animal kingdom. I know you have been anxious for Dr Shreeve to speak.

(*Dr Shannon*) Would you like to talk about the importance of systematics and the threats posed to the United Kingdom by the hazards of exotic diseases.

(*Dr Shreeve*) I see the threats in two ways from outside this country. Firstly, in relation to the increasing movement of animals and animal products, there is a risk of bringing in pathogens, and we need to be able to identify them. Also, there is an increasing tendency to farm exotic species, such as leamas. We need to maintain expertise not only to predict problems that might arise—parasites or bacteria or whatever—but also to do something about them when they do arise.

248. Are you all satisfied that there are the human resources available to meet your needs?

(*Dr Shreeve*) We would always say there are never enough resources to meet our needs.

249. I was speaking particularly of human resources, because one of the points that has been made to us is that interest in systematics has declined in higher educational institutions for a number of reasons. New light is being shed on it from an exciting new area. That tends to shift the attention of the young and the young teachers. Are you getting people coming forward or do you train them on the job?

(*Dr Shreeve*) We tend to train them on the job, but we also send people on appropriate courses.

Earl of Cranbrook

250. My Lord Chairman, we heard some evidence on the training aspect yesterday at the Natural History Museum, where it was suggested that it took 15 years to train a good taxonomist. I wonder whether Dr Shreeve is of that sort of opinion of the training needs.

(*Dr Shreeve*) You must realise that the taxonomy that we do at the Central Veterinary Laboratory is intimately bound up with the R & D which we carry out to underpin Government policy. Fifteen years is a very long time, but nevertheless, it does take several years to develop the appropriate expertise, depending on whether you are talking about gross morphology of bacteria or sequencing viruses. It does take time.

Chairman

251. I am trying to work us back to the list of questions you were sent. One was a preliminary list and the other was the questions which we thought we might have today, and one of them, which is very important to us, is whether the state of systematic biology research and training in the United Kingdom is adequate for our present and needs. What is the view of MAFF on that, or are you so far removed from it that it is of little concern?

(*Dr Shannon*) I think our impression is that we are having to provide more training on the job than was the case in the past, though that is obviously very difficult to quantify, and clearly we would be concerned if that were to continue indefinitely. In other words, we do want to have people trained so that we spend less time training them ourselves. We would argue that the policy on training is very much one for the Department of Education and Science and the universities, but we do have an interest in being able to recruit well-trained staff.

252. How do you see in this regard your role as the paymaster, at arm's length, under the new arrangements for Kew, for example?

(*Dr Shannon*) We fund a mixture of activities at Kew: curation and research and horticultural training. That obviously makes some contribution to the overall training in the United Kingdom, but I do not think we would claim—and I do not think Kew would claim—that training of taxonomists is a primary part of their responsibility.

253. From what you have said, you are quite content to have Kew under one management and funded by MAFF on the one hand, and the Natural History Museum, with its interests in this field—admittedly there is a working arrangement between them based on an agreement—funded by the Office of Arts and Libraries. It makes little difference to your work?

(*Dr Shannon*) We want to be assured that the agreement between them is one that is adequate for the purposes, but having got an adequate agreement, we do not see any inherent difficulties in Kew being funded by the Ministry and the Natural History Museum being funded through the Office for Arts and Libraries. Clearly, there is a need for a division of labour, and one would want from time to time to

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review that division of labour and to ensure that it was working effectively.

254. Are there good relationships—which there must be if you are to do your work well—with for example, the AFRC? I notice you draw particular attention to, for example, weeds, and the AFRC has, I think, disposed of its Weed Research Station, has it not?

(*Dr Shannon*) Yes. I hope we have a good relationship with the AFRC, and I believe we have.

255. Does that abolition in any way impede your work?

(*Dr Shannon*) We have two responsibilities, I think. We have under the Weeds Act a responsibility to control five particular weeds, but we also have responsibilities for research in relation to weeds and control in relation to agricultural crops. Certainly the closure of the Weed Research Organisation did reduce the amount of effort that was going into weed research, but some of that effort is now being taken up by the Institute of Arable Crops Research at Long Ashton and possibly Rothamsted.

256. So you feel adequately covered from that point of view?

(*Dr Shannon*) Yes, I think so.

Lord Walton of Detchant

257. The Medical Research Council has suggested that taxonomy should include not only the identification of organisms and species, but also cell types and molecules such as enzymes and antibodies. Do you regard that as falling within your particular remit in relation to prevention of animal disease and the issues of possible transmission to humans? Can I follow that up by one other point only? Does that include, for instance, the work on Prion protein in scrapie and the reasons why this may not be transmissible to man? Does this come within the ambit of this inquiry?

(*Dr Shreeve*) I think it should do, yes. We devote resources to sequencing, for instance. We are looking at various organisms: *Salmonella*, for example. By doing this we improve diagnostic methods, increase our understanding of the pathogenesis of disease, and aid epidemiological investigations by developing appropriate markers.

Chairman

258. Can we return to the list of questions which you had before you for today, because we have not really covered them and I doubt whether we will be able to in time. If you could give us a note on some of these, it would be helpful, but there are two that interest me in relation to Kew, which are numbers 8 and 9. The first one relates to whether you regard the funds as being adequate for Kew to do the research which is necessary and raises the question also as to whether you have any views on admission charges in connection with that, or whether you think that is a matter purely for the trustees, which I suppose is the doctrine. The second relates to the research funding at Kew and whether it is eligible for research council support.

(*Dr Shannon*) The MAFF grant-in-aid to Kew is intended to provide adequate funding to enable the Board of Trustees to fulfil their obligations under the National Heritage Act of 1983, including those for research. However, as you might expect, this does not preclude Kew from seeking alternative sources of funding, and indeed, it has established, I think, two bodies—the Kew Foundation and Friends of Kew—with the expressed interest of increasing its funding from non-governmental sources. The governmental sources of funding for Kew amount to something like 85 per cent of its budget at present. The revenue from admission charges—and I think this was a specific question—is used to underwrite the resource costs of keeping the gardens open to the public. In other words, the cost of admission is about equivalent to the cost of opening the gardens to the public and providing that amenity.

259. The question asked whether, if they were short, would they be justified in increasing the charges?

(*Dr Shannon*) The admission charges at Kew have been a matter of considerable discussion and indeed, the trustees do look at the cost of admission from time to time. They have done some market research on what the market will bear, and also they have done comparisons with what the admission charges are for comparable attractions in London, and the admission charge is set relative to those two criteria.

Lord Flowers

260. Does the Department take into account the earnings of Kew through these other channels in settling its annual subvention?

(*Dr Shannon*) The Government has tried to protect Kew and not to take into account the income it achieves by its own methods in setting the basic grant-in-aid to Kew.

261. You have tried; have you succeeded?

(*Dr Shannon*) I can quite easily give you the figures for Kew of the expenditure. It is a mixture of running costs and capital improvements. The run of figures we have for the last three years for example on running cost are £10.4 million in 1989-90, £11.2 million in 1990-91 and an expectation of £13 million in 1991-92. In addition to that, we are funding capital works at Kew in the same three years of £1.2 million, £2.2 million and £2.5 million. Kew has had a very substantial rebuilding programme in relation to its various facilities: the Palm House, the Princess of Wales Conservatory and the Sir Joseph Banks Building.

262. What order of magnitude are the other earnings?

(*Dr Shannon*) About 15 per cent, obviously. I cannot be precise about the split between gate receipts and income from research contracts and the like. I should add finally that 50 per cent of the grant-in-aid to Kew is for research. That is roughly £6 million a year, and about £3 million of that is for systematic biology.

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Chairman

263. May one ask another point about the financing of systematic biological research? From all that has been said on the animal and plant side, it is quite clear that what you do in MAFF is of enormous benefit to the agricultural industry in this country. Does that agricultural industry bear its fair share of the costs of supporting some of the work on systematic biology?

(*Dr Shannon*) It increasingly has been asked to make a contribution towards the cost of systematic biology from which it benefits. For example, in relation to national listing of varieties of crops, the industry now bears a very substantial part of the cost of that. In relation to specific collections of genetic material, there are, if you like, welcome contributions from the industry. ICI is making a contribution to the cost of the Vegetable Gene Bank, a number of bodies are making a contribution to the cost of the National Fruit Collection and Horticultural Development Council, but also another organisation has been established, the Brogdale Horticultural Trust, which it is assumed will popularise and make some contribution to the systematic biology in relation to the fruit sector of the industry.

Earl of Selborne

264. Perhaps I ought to declare an interest in the Brogdale Horticultural Trust. Leaving that aside for the moment, it does seem that, over the years, clearly, the Ministry has had to take an increased interest naturally in plant genetics conservation. You have found yourself involved in the Vegetable Gene Bank really because it was clearly a resource which had to be maintained. You have described the evolution of the National Fruit Collection, and you are involved in the Pea Gene Bank. This is hardly representative of agricultural crops as a whole, of course. Do you have a strategic plan for ensuring from one source or another that all these crops of agricultural importance are adequately covered? In your introductory remarks you did suggest that your thoughts were in an evolutionary state. You were discussing with other Departments and Government how you might proceed. Do you see a need to change? Do you perceive that some of these other gene banks are potentially under threat?

(*Dr Shannon*) Our contribution to some of the gene banks is to meet our international obligations, and by contributing to those we open up the other gene banks around the world to United Kingdom interests. So in some senses the Vegetable Gene Bank and one other collection is part of the international set of collections. So by making our contribution to that, we do open up a range of other gene banks. I think the Netherlands has a major potato collection, as indeed does the Scottish Office. So I do not think we see ourselves in trying to fund every gene bank that is put in front of us. We would see some sort of rational approach to ensuring that the United Kingdom industry had access to the gene banks that were required, and we do this through funding some and thereby having international access to others.

265. What is the international forum to which you would discuss whether the European or world cover in the temperate crops in which we are interested was adequate?

(*Dr Shannon*) There are various fora at the moment, and some of these are more satisfactory than others. It is difficult to be precise at this point. The FAO has some responsibilities. The IBPGR, I think it is, has some responsibilities in Europe. I think the system is creaky, to say the least, and it is in this context that we have been trying to make a contribution to the international dimension.

Lord Porter of Luddenham

266. May I follow that up? That was what I was getting at in my question a while ago. What is the national forum which speaks for the United Kingdom on whatever the international forum is? You mentioned it might be the ABRC, it might be the Cabinet Office. I asked whether it was MAFF. If we are entering into international European discussions of this kind, who speaks for the United Kingdom?

(*Dr Shannon*) When I mentioned the Cabinet Office or the ABRC I was talking more about the future. At the moment the arrangements in the United Kingdom are very much informal ones of those responsible for gene banks coming together, but the Ministry has taken a lead and is chairing that informal group of curators, I suppose, largely, with individual gene banks. We are chairing that forum and taking that discussion forward in Europe and with FAO.

267. So MAFF is taking the responsibility for pulling it together as far as this country is concerned?

(*Dr Shannon*) Yes, initially in relation to our own narrower responsibilities. There is another level at which the United Kingdom needs to have a policy which embraces other Departments. Especially the Department of the Environment and possibly the Research Councils. Here too we are taking the lead in developing policy.

Lord Whaddon

268. Dr Hardy mentioned right at the beginning that with the unified market, there would be an escalating need for work of this nature. Could he put a figure to this, because this is almost upon us? Just what will he be needing in the way of increased resources and what penalties does he see us suffering if we do not do it?

(*Dr Hardy*) It is very difficult to make precise predictions. To give you some sort of feel, we are currently putting in about 40 staff years each year in support of the plant health policy division within the Ministry in direct support of plant health policy and activities. We are being asked as a laboratory to increase that by a further 20 staff years a year, therefore a 50 per cent increase in the next two or three years. Whether that will cope with the anticipated workload it is very difficult to say at this stage, but the Inspectorate itself is being increased in size by a commitment from the plant health policy division. Only time will tell, but it is quite clear that there will be a fairly dramatic increase in the amount of technical support which, as an integral part, requires systematic biology as a very important cornerstone.

269. If we do not do it, what penalties will we pay?

(*Dr Hardy*) The penalties I think will be the great difficulties that growers in the United Kingdom will

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find in terms of adequately guaranteeing the plant health of their material for movements within the EC, whether it is within this country or between other Member States.

Chairman

270. Could one follow that up by asking are you confident that you will be able to get the manpower when you want it?

(*Dr Hardy*) The provision for the funding for that manpower is already programmed into the rolling programme within the Ministry's funding. We put in a bid into that.

271. Are you confident that you will get the people even when you have the money, to be more explicit?

(*Dr Hardy*) I am confident we can do it if the funds become available.

272. The people exist?

(*Dr Hardy*) Yes. It goes back to what we were saying about training. Clearly, we do a large element of in-house training as far as staff are concerned, and looking at the expertise of people coming into the system at the moment, I would not anticipate decreasing the amount of in-house training that we will require, but we would cope with it.

Lord Walton of Detchant

273. Can I be clear this is to be funded by funds made available from each of the Member States, not EC funds?

(*Dr Hardy*) It is the Ministry of Agriculture, Fisheries and Food internal funds.

Lord Flowers

274. Can I explore one other issue which I am not clear about? When we have been talking with the Natural History Museum, we have identified an issue which I would like to compare with Kew. The Natural History Museum can apply to the research councils for research grants and Kew can. It is assumed by the research councils when they give grants to bodies—universities, for example—that the laboratories in which the work is done are well found, that is to say, the basic facilities, the on-going general research, is in place and is paid for. In the case of universities, of course, scientific advice is sought about the amount of research money that should flow into them. It appeared with the Natural History Museum that really there was very little advice to the Office of Arts and Libraries about how much money should be given to the NHM to look after the maintenance of the research base of the museum as distinct from maintenance of museum work. What is the comparison with Kew? Kew can apply for research grants. Kew gets a general grant from the Department. What sort of advice do you take in collaboration with the research councils that Kew is in a position to make full use of research council grants that is backed up properly by your basic support?

(*Dr Shannon*) Kew gets a grant for its running costs. It also in recent years has had substantial sums of money for capital improvements. Indeed, it will have the figure I gave you. It will have a substantial programme to extend the Jodrell Laboratory. Once that is complete it will be a well found laboratory and, certainly in terms of comparison with universities, I would have thought it would be very well catered for. In terms of advice, it does have a Board of Trustees, and the Board of Trustees has a Scientific Advisory Committee, chaired by Professor Cocking from the University of Nottingham, with a number of other eminent scientists on it. So there is advice to Kew on what its requirements are. That then comes forward to the Ministry and we examine their proposals and make a judgement on the case that is put to us. I have an annual meeting at Kew and look around the laboratories so that I am in a position to advise the Minister on the strength of the case and the need that has been identified.

275. Your answer is almost exactly the same as that given by the OAL in the case of the NHM. You have more scientific expertise around the Department to judge these things than they do.

(*Dr Shannon*) Yes.

276. Do you take into consideration the scientific advice you receive through your home-grown channels?

(*Dr Shannon*) We also have instituted a visiting group (or peer group) review procedure in relation to Kew. So we also have a visiting group report, which gives a view on what the requirements are. Although that report is to the Board of Trustees, it is also seen by the Ministry.

277. Finally, do you have discussions with the research councils about what their view is of the need for funding of research at Kew?

(*Dr Shannon*) I have not had specific discussions with the research councils. In fact, one question which was raised is whether Kew is in a position to apply to the research councils for a research grant. My view would be that it should be in a position to, and I am not quite sure whether it is permitted. I would need to check on that.

Lord Flowers] I was under a misapprehension in that case.

Chairman

278. We have covered a great deal of territory, but even so, we have left some of the questions that we put to you unanswered. May I in thanking you and your colleagues for coming, also invite you, if you would, to look at some of those unanswered questions and let us have a note on them?

(*Dr Shannon*) We would be pleased to do so.

Chairman] I would be most grateful. Thank you very much indeed.

*30 April 1991]**[Continued]***Memorandum submitted by the Scottish Office Agriculture and Fisheries Department****SUMMARY**

The Scottish Office Agriculture and Fisheries Department funds research on systematic biology mainly:

- (i) at the Royal Botanic Garden, Edinburgh, through taxonomic studies and the maintenance of living and preserved collections;
- (ii) at the Department's Agricultural Scientific Services laboratory, in support of statutory responsibilities for crop cultivar testing;
- (iii) at the Scottish Crop Research Institute, as part of wider programmes of research in crop genetics and breeding, and in studies of plant pathogens and pests.

Funding for systematics research at the Royal Botanic Garden, Edinburgh, has been maintained, compared with the level of funding by the Department for agricultural research generally. Taxonomic research, especially that done within agricultural research, has been subject to reductions along with other traditional scientific disciplines to release funds for new areas of research. In some cases, eg molecular biology, image analysis and information technology, this new research is likely to be of application in, and considerable benefit to, taxonomy.

The programme of taxonomic research in the Royal Botanic Garden, Edinburgh, is the responsibility of the Garden Trustees in conjunction with the Regius Keeper. There is extensive consultation within the UK and further afield to ensure that the programme is scientifically sound, relevant, and well co-ordinated with others. The programme aims to strike a balance between developing scientific opportunity and meeting user-led demand for work on plants of ecological or economic importance. There is scope for the development of cross-disciplinary links between taxonomy and those many disciplines which will benefit systematics research. This is being actively pursued.

Education in taxonomy has declined at the undergraduate level but is capable of being enhanced at postgraduate level. The research organisations funded by the Department are available and receptive to students wishing to conduct systematics-related research; and the Royal Botanic Garden is currently planning jointly with Edinburgh University a MSc course in systematics.

INTRODUCTION

1. According to the Systematics Association, systematics involves "the naming and classification of all kinds of organisms, whether past or present, and understanding how they have evolved through time and function ecologically, biochemically and physiologically". Systematics research might be taken in a narrow context to include only the testing of hypotheses by experiment—ie experimental taxonomy—and the application of new technology to systematics but this would exclude much of the monographic work and studies of diversity which form the core of taxonomic work. ("Systematics" and "taxonomy" are used interchangeably here.) For present purposes systematics research is being more broadly interpreted to embrace related activities such as the production of catalogues of the organisms of a particular area, and the development and maintenance of collections of living and preserved specimens.

2. The Scottish Office Agriculture and Fisheries Department funds research on systematic biology mainly:

- (i) at the Royal Botanic Garden, Edinburgh, through taxonomic studies and the maintenance of living and preserved collections;
- (ii) at the Department's Agriculture Scientific Services laboratory, in support of statutory responsibilities for crop cultivar testing;
- (iii) at the Scottish Crop Research Institute, as part of wider programmes of research in crop genetics and breeding, and in studies of plant pathogens and pests.

There are some additional elements of systematics research within the research programmes conducted by the other organisations funded by the Department. These, and other research and statutory activities funded by the Department, are dependent for their success on the existence of reference collections in the UK and abroad which are used: to provide identification services eg for food and soil micro-organisms, unusual pests and pathogens; to supply material of potential interest for taxonomic, genetic, physiological or pathological studies; and as depositories for novel organisms.

3. The questions raised by the Sub-Committee are answered below. In some cases the questions are answered generally; in others, the questions relate more specifically to the roles of particular organisations and are answered in a more specific context. The Department is aware that the Regius Keeper of the Royal Botanic Garden, Edinburgh, has been invited separately to submit written evidence to the Sub-Committee and detailed information about the Garden is excluded from this paper. The Department is also aware that other Government Departments, including the Ministry of Agriculture, Fisheries and Food, are submitting evidence to the Sub-Committee.

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i. *What is the utility of systematic biology research?*

4. The Department sees the utility of systematic biology research as:

- contributing to scientific knowledge;
- providing the basal reference system of biology with an accompanying descriptive nomenclature and terminology;
- enabling scientists engaged in other research, through aids such as Keys, databases, expert interactive systems, and reference collections of specimens, to identify individual organisms unambiguously;
- leading to the understanding of the evolutionary and genetic relationships between individual, and groups of, organisms;
- providing a basis for assessing biodiversity in natural and managed communities;
- accumulating living and preserved material and related information for reference purposes;
- providing an historic record of organisms that may already be, or may become, extinct;
- supplying material for research purposes or for potential exploitation in medicine, agriculture, horticulture, forestry and industry;
- providing a resource for educational, training and amenity purposes.

5. The end product of modern systematics research is generally a system of classification of the organisms under study from which the identification of an individual organism will reveal a set of character attributes (morphological, anatomical, cytological, biochemical and even molecular) which it possesses. This 'predictivity' of the properties of a relatively unfamiliar organism lies at the heart of the usefulness of systematics research to all other areas of biological research. The more peripheral information which can be included (which may not necessarily have been derived from taxonomic studies) the more useful is the data set likely to be. However, the production of transgenic organisms, introducing characters previously alien to a particular organism and thus breaking this pattern of predictability, poses a major challenge to systematics.

ii. *Does the need to specify particular organisms in connection with eg intellectual property rights, regulatory provisions, etc, impinge upon your work?*

6. The Department's Agricultural Scientific Services laboratory conducts "Distinctness, Uniformity and Stability" (DUS) tests on agricultural and horticultural crop cultivars. These tests provide information towards entry to the National List and on which Plant Breeders' Rights (PBR) may be granted. PBR provide protection against multiplication of plant material without the agreement of the Breeder. With information from additional tests within the National List Trials, a new cultivar may be adopted onto the UK National List. This permits sale of the cultivar in the UK. Entry onto the National List leads after two years to entry onto the EC Common Catalogue of crop cultivars when a cultivar may be traded throughout the EC whether or not it has been entered on the National List of a particular Member State.

7. Plant Breeders' Rights and the National List system depend upon the ability to be able to discriminate between plant genotypes on the basis of a comparison of a set of morphological or other characters. Within the UK the laboratory has responsibility for the DUS testing of vegetable cultivars including potatoes, peas, swedes, radishes, celery and onions. The laboratory also conducts systematics research on these crops with the aim of improving the efficiency with which new cultivars may be distinguished.

8. Research in plant breeding funded by the Department at the Scottish Crop Research Institute could lead to the production of new cultivars. Normally the establishment of Plant Breeders' Rights would be the responsibility of the Institute's commercial partners but it is possible that the Institute would itself wish to register material that its partners may have decided not to exploit. Such material would be subject to the normal National List Trials procedures.

9. Research in any of the organisations funded by the Department could lead to the production of novel organisms or gene combinations which may be patented.

iii. *Is the level of UK research appropriate? If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?*

10. The main research expenditure by the Department on systematic biology is at the Royal Botanic Garden, Edinburgh. Research there under the broad description of "botany" amounted to £1.7m in 1989-90. This compares, in broad terms, with a spend by the Department in the Scottish Agricultural Research Institutes and the Scottish Agricultural College of £2.6m (fec) on plant genetics and breeding, £3.5m on plant physiology and £3.3m on plant pathology. However, because the different activities of the Garden (research, education and training, amenity) are so closely integrated, it is difficult to identify what part of the Garden's grant-in-aid is spent on research alone. The living collections, the preserved collection and the library collection all constitute the raw material for taxonomic research; and without research the justification is lost for maintaining these facilities and the secondary uses which depend on their existence. The various gardens are maintained primarily for their scientific value and only secondarily for amenity—they house the living

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plant collections which are integral to the scientific research activity. Total funding from the Department for the Garden in 1989-90 was £4.6m and this may be closer to the real "research" spend.

11. Systematics research at the Department's Agricultural Scientific Services laboratory concentrates on cultivar taxonomy. This amounts in total to approximately £30k per year. Because of limited resources and variable demand from other higher priority activities such as the responsibility to conduct National List Trials, this is conducted on an irregular basis when time is available.

12. At the Scottish Crop Research Institute and other organisations funded by the Department systematics research is not a primary objective but is conducted where necessary as an adjunct to the commissioned research programme. Because of this no overall cost is available.

13. There is no generally accepted method of determining an appropriate level of research for a particular discipline. Funds may be made available to increase research effort in a particular area:

- (i) to develop or exploit new opportunities;
- (ii) to increase the volume of effort in a priority area;
- (iii) to remove a constraint that is hindering research in other areas.

Because of the opportunities that they may offer, exciting areas of new science tend to receive a greater share especially of short-term funding than more routine, though important, work. During a period in which the funding of research has been subject to severe constraint, cash can only be released for these new initiatives at the expense of "old" science. If systematics is to receive a greater share of funding than at present from within the Agriculture Vote, the case will have to be made against other pressing demands for additional effort in new science, and in areas of public concern such as animal welfare, land use studies, climate change and environmental pollution. It is perhaps ironic that the molecular biological techniques now available for exploitation in systematics research may have been developed through funds made available by reducing the effort on taxonomy.

iv. Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate, eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?

14. The Royal Botanic Garden is funded by grant-in-aid and the Department does not determine the Garden's programme of research. This is for the Board of Trustees and the Regius Keeper although the basis of selection of research is queried regularly. The work programme of the Garden is decided only after advice and information are sought from a range of sources, and these are taken into account. Formal advice is received from Visiting Groups (the last one was in 1983 and one is planned for this year), and the Regius Keeper has recently established a small Scientific Advisory Group. Within the UK there are regular meetings between RBG Edinburgh, RBG Kew and the Natural History Museum. Internationally, the Garden is part of the informal network of Botanic Gardens between which there is good communication. The RBG Edinburgh programme seeks to achieve a balance between working on specific groups of higher plants, ferns, mosses, algae and fungi, including some of economic importance, and the study of the floras of particular geographical areas to catalogue plant diversity; and between user-led demand and scientific opportunity. The Garden is currently preparing its first Corporate Plan and as part of this activity is reviewing strategically all of its various activities. Advice is being sought widely as part of this review.

15. Because communication amongst the community of research workers is good, needless overlap or duplication is avoided. The International Union for the Conservation of Nature, together with the World Wildlife Fund for Nature have issued a "Botanic Gardens Conservation Strategy" which aims to:

- "identify the priority tasks that botanic gardens need to undertake as their part in implementing the World Conservation Strategy;
- propose effective ways in which the botanic gardens of the world can work together to achieve these priorities; and
- provide a coherent set of principles and procedures that will allow botanic gardens to plan their part, alongside other institutions, in achieving the maximum amount of long-term conservation of plant species and populations and focus public attention on the issues of conservation through appropriate educational displays and programmes."

The issue of "guiding principles" might formalise the informal relationships and complementarity which already exist amongst those organisations concerned primarily with taxonomic research but it is doubtful how useful this would be. There may be a stronger case for looking more holistically, even within a UK context, at the relationships between taxonomy and other disciplines, and hence at the relationships between the organisations that conduct this potentially complementary research. A link exists between the Department's Agricultural Scientific Services and the AFRC Institute of Plant Science Research, and links between the RBG Edinburgh and the Scottish Crop Research Institute and other plant science institutes are being actively pursued.

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16. Within the UK work in relation to Plant Breeders' Rights and the National List is fully coordinated. The National Institute for Agricultural Botany is responsible for cereals and field crops; the Department's Agricultural Scientific Services laboratory for potatoes and vegetables; and the Department of Agriculture for Northern Ireland is responsible for grasses and clovers. There is a move towards rationalising responsibilities within the EC.

17. Systematic biology research at the Scottish Crop Research Institute, the other Scottish Agricultural Research Institute, and the Department's Fisheries Research Services laboratory, relates to their commissioned research programmes which are coordinated with other research organisations through a variety of mechanisms. At the Scottish Crop Research Institute there is research to develop diagnostic tests for varieties of a range of crop species used in their genetic and breeding studies; the Zoology Department is interested in genetic and evolutionary relationships mainly in nematodes and aphids; and mycologists are studying relationships within the economically important fungus genus *Phytophthora*. The Rowett Research Institute is conducting taxonomic studies of rumen bacteria and holds on an informal basis the UK collection of these organisms. New soil fungi and protozoa have been identified by workers at the Macaulay Land Use Research Institute. The Scottish Agricultural Statistics Service is investigating the concept of the "minimum distance" that should separate a new variety from all established varieties in respect of at least one character. And finally, the Department's Fisheries Research Services laboratory is concerned with the sub-division of fish species into reproductively distinct and genetically differentiated populations, the biological units on which fisheries management aims to focus.

18. The quality of human and other resources at all of the organisations mentioned above are already, or will be, subject to Visiting Group Peer Review.

v. What is the extent of our need for reference collections including foreign material as a basis for systematic research? Is provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?

19. Even though Botanic Gardens may specialise in particular areas, systematics research cannot be undertaken in isolation. There is a considerable exchange of material between the RBG, Edinburgh, and other collections. Over the past five years the Garden Herbarium has received on average around 150 loans each year, with each loan containing on average around 50 specimens—ie around 37,500 specimens received on loan in total over that period. The Herbarium has itself made almost 170 loans each year, each loan containing on average around 35 specimens. In addition, the Herbarium has received annually over the last 5 years almost 8,000 specimens as donations, and has gifted around 4,000 per year to an average of 40 institutes each year. The volume of material received by, and sent from, just one Garden is thus considerable. All of this material is being used for systematics research purposes.

20. The Herbarium at the Garden is approaching full capacity. Plans for an extension have been prepared and funding approved in principle. If novel methods of DNA storage are developed in due course, a facility for storing such material will be required. One reason for providing capital funds to the Garden is the recognition of the international importance of the material stored there.

21. For the registration of new cultivars of each of the crop species tested at the Department's Agricultural Scientific Services laboratory, a collection is maintained consisting of material of "common knowledge" (ie extant varieties on the UK National List and EC Common Catalogue) together with a much wider range of material used to derive character sets for the testing work. The laboratory needs access not only to cultivated but also to as wide a range as possible of wild type material which can be used as controls for the expression of characters. Some of this material is quite rare. These collections are adequately stored and curated. The laboratory has a particular responsibility to supply material to other testing authorities and also makes it available to plant breeders and other scientists. There is, for instance, a close link between the laboratory, who conduct National List testing of peas, and the AFRC Institute of Plant Science Research who have a research programme on pea genetics. The laboratory also requires access to material and identification services in relation to its interests in plant health, especially for the identification of non-indigenous plant pests and pathogens.

22. All of the Scottish Agricultural Research Institutes and the Scottish Agricultural College also require access to identification services and source material, especially of pathogens and pests, for research studies. The Scottish Crop Research Institute has additional requirements for access to living genetic material for use in its crop breeding and other research. All breeders must maintain working collections for their programmes but the Institute has particularly important collections of potato germplasm (held at high health status) and virus type specimens. They also hold a working collection of blackcurrant raspberry and blackberry germplasm of high health status. With all of these collections there are contacts and exchanges with collections abroad.

23. Finally, all of the organisations funded by the Department may at some stage produce genetically manipulated micro-organisms, cell lines or plasmids, all of which may be subject to patent protection. Such material is required to be deposited in a culture collection and a number of different collections within the UK

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have now been designated for this purposes. Most of these collections also provide identification services and source material and it is clearly important for the continuing research funded by the Department that such services should remain in existence.

vi. *What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research taking cognizance of the full range of new developments in this field?*

24. "New methods" are presumed here to include techniques derived from molecular biology, image analysis and information technology although taxonomy can benefit from advances in a wide range of disciplines.

25. Patenting organisms, plasmids or gene sequences relies on DNA sequencing and thus molecular biological techniques are integral to systematics in this context. However, the same techniques are seen more generally as being at the stage of providing a complement to, and enhancing, traditional morphological and anatomical, numerical and biochemical approaches to classification. It is likely to be particularly useful in the elucidation of genetic relationships between closely related groups of organisms. Molecular biological methodology is expensive and must be justified against other claims on resources. Some would argue that there are still so many of the world's species to describe using traditional methods that adoption of molecular biological techniques in systematics should not yet receive a high priority. Molecular biology might appear to be particularly applicable in the context of cultivar discrimination but even in this context it is likely to be most useful in distinguishing between clonal cultivars, useful for true-breeding crops, and least useful for out-breeding crops. Co-operation between taxonomists and molecular biologists in plant science institutes and universities would seem to be the most productive way forward at the present time. If it should prove possible to resuscitate "usable" genetic information from preserved material, the whole approach to preservation will require assessment.

26. Image analysis, on the other hand, is probably close to the stage where it can be applied productively and widely in systematics. Differences between organisms that can be defined in terms of size, shape or ratios of particular measurements are especially suited to detection using image analysis and some applications have been in use for several years. However, the practised human can be extremely rapid in distinguishing between particular features in different organisms and it is perhaps only now that hardware and software are becoming available at reasonable price to compete with human dexterity and ability to discriminate. Systematists appear to be aware of the potential.

27. Information technology is almost certainly not being applied as widely as it should. Apart from the construction of databases containing conventional records as would be found eg in a flora, there is enormous scope for linking this with visual material showing aspects of morphology, anatomy and even the ecology of particular organisms. Additional information, not necessarily derived from taxonomic studies, would make the database even more valuable. All of this information could be made available electronically on a world wide basis. There is also scope for tackling the complex problem of discrimination, especially the translation of a set of measured characters into a systematic description of an organism and the ability to compare it with another organism to test for similarity or difference. The likely constraint on advances in this area is the availability of people with adequate systematics and information technology training to be able to understand in depth the nature of the problems in systematics which information technology could tackle. The RBG, Edinburgh is already moving to strengthen this area of its research.

28. It is arguable that multidisciplinary research is now better handled in teams rather than trying to seek "multidisciplinary people". The optimal means for taxonomy to access and exploit advances in other disciplines is likely to be through a large element of collaboration and networking rather than through trying to provide all expertise "in-house".

vii. *Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?*

29. "Institutions" provide the core of stability to taxonomic research that is essential to accompany the custodianship of major collections of living and preserved material. There is also a massive amount of bread-and-butter taxonomy still to do, and that again is best done in core, relatively stable and long-term programmes that "institutions" can provide. They can also provide associated continuity of expertise for "consultancy" (eg identification) purposes necessary to many biological researchers working on a limited range of organisms. The absence of such points of reference may mean that research workers who are not trained systematists find themselves obliged to undertake taxonomic research with the danger that such work will be done inefficiently and even incorrectly.

30. The Department is particularly conscious at the present time of the "continuity" problem devolving from the retirement of Professor Hawkes from Birmingham University when it was decided not to continue there with his programme of work on the taxonomy of the Solanaceae. The material that he had collected was held in quarantine isolation. It started to deteriorate as soon as it stopped being worked, and a rescue operation is now under way to put as many accessions as possible through quarantine and into the

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Commonwealth Potato Collection held at the Scottish Crop Research Institute. This is being achieved over a period of 4 years at a cost to the Institute of £100k. However, Research Institutes must decide on priorities and are probably less secure as repositories of genetic collections than those organisations whose primary purpose is concerned with systematics. Indeed, the collection of virus type specimens held at the same Institute will pose a particular problem when the researcher associated with this work retires shortly. The collection of plant viral isolates has been built up as a result of virological studies at the Institutes over several years. The Institute has taken a leading role in determining a classification system for viruses and the collection is of particular importance because there are no definitive national, EC, or international collections of viral type specimens. Some of the material cannot be preserved but must be maintained through passage in living plants and, with no formal depository in the world, may be vulnerable to loss if the Institute decides that this area of work should not receive the same priority in future.

31. There is considerable scope for collaborative work between "core" institutions whose primary objective is to conduct research on systematics, and research institutes and universities which can conduct related, perhaps more speculative research of relevance to, or in support of, taxonomic studies. Some such links have already been mentioned in paragraph 15. In a more applied context, the RBG, Edinburgh, has joined together with Edinburgh University, the Institute of Terrestrial Ecology and a private company to form the "Edinburgh Centre for Tropical Forests". This consortium will be bidding for major research contracts on tropical forestry, with RBG providing the systematics base for any such work.

viii. *If research is to be continued who pays?*

32. Clearly there are attractions in the prospect of sharing expenses at European or international level for large projects but the Department is not in a position to influence this directly.

33. Government is likely to continue to provide the major component of funding for systematics research. The extent of this funding will depend ultimately on the importance which Ministers collectively attach to it. In recent years the budget of the RBG, Edinburgh has been maintained at a time when the research budget for the Scottish Agricultural Research Institutes and the Scottish Agricultural College has declined relatively. Over the 5 years 1986-87 to 1990-91, funding for research at the Garden has increased in cash terms by 56 per cent whilst equivalent funding at the Institutes and College has increased by 11 per cent.

34. The cost of the provision of services to industry is generally recovered through fees. Industry is likely to fund systematics research leading to the protection of their investment in genetic engineering but it does not at present seem to be motivated towards making additional contributions to systematics research and related activities. This presumably reflects their perception of commercial opportunity at the present time.

ix. *Is teaching adequate?*

35. It would appear that undergraduate teaching of taxonomy has declined in universities as botany and zoology courses have been replaced by courses in biological sciences. This is a reflection of the glamour and potential exploitability of new branches of science that has been at the expense of areas such as whole-organism physiology and taxonomy. Teaching or training at the postgraduate level could compensate for this and it will clearly be a challenge to make a subject such as taxonomy more attractive and exciting at this level. The research organisations funded by the Department are available and receptive to accommodating students with an interest in taxonomic research. There is obvious scope for a link between the Garden and Edinburgh University to offer formal education at undergraduate or postgraduate levels and joint planning for the provision of an MSc course is well advanced. In addition, The Royal Botanic Garden offers training and educational opportunities for specialists, schools and the interested public for whom there is a major outreach programme.

x. *What can we learn from abroad, especially the USA?*

36. It is the job of the organisations which the Department funds to keep abreast of developments abroad and to assess their relevance to their own research or other programmes. A feature of the USA approach to systematics on the plants side has been to fund centres of excellence such as Harvard and Missouri which combine major living and preserved collections with information systems, outreach programmes, teaching and training. This combination of university and Garden function stimulates the cross fertilisation of disciplines and activities that is not fully realised yet in the UK but which is likely to be essential for the future development of systematics as a discipline in its own right, and for its many applications.

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Examination of Witnesses

DR T HEGARTY, Scientific Adviser; MT K W MOORE, Head of Division, Education, Advisory Services and Research; and DR D INGRAM, Regius Keeper, Royal Botanic Garden, called in and examined.

Chairman

280. Thank you very much, Dr Hegarty, Mr Moore and Dr Ingram for coming today. Thank you for your very carefully worded written evidence, which tries to respond precisely to the questions which were put to you. You have also had, I imagine, the list of questions which we have in front of us, have you? May I ask you whether you would like to make a general statement to begin with, you or any of your colleagues?

(*Dr Hegarty*) If you would take the paper as read, Chairman, that is all really we need to say, which will save you time. Can I just introduce Mr Moore on my right-hand side, who is Assistant Secretary within the Department, with responsibilities for agricultural research, and Dr Ingram, who is Regius Keeper at the Royal Botanic Garden, Edinburgh, in other words, its Director, who is not a civil servant, not part of the Scottish Office. The RBG Edinburgh is an NPDB and Dr Ingram is therefore here in an independent status. He has also of course put in written evidence to you.

281. Yes indeed. We gathered that. Perhaps I could draw your attention to your written evidence, which on page 5 in paragraph 13 makes a remark which resonates with me very much. You say, "It is perhaps ironic that the molecular biological techniques now available for exploitation in systematics research may have been developed through funds made available by reducing the effort on taxonomy." That suggests that the question of balance between these two complementary approaches is of critical importance and is not ideal at the present. Is that the case?

(*Dr Hegarty*) I would not necessarily say it is not ideal. We have to accept there is a changing scene, and whilst there is still a demand for conventional taxonomy—and I am sure Dr Ingram will say there is a massive demand—whilst that perhaps has declined in some areas of funding, nevertheless, Dr Shannon was referring to the pick-up of systematics around genetic engineering, for instance, so that we are perhaps seeing a down on one side and an up on the other.

282. I was referring to the balance between those two. Is it right or is it going wrong? Is there a lack of old-fashioned systematic work now to sustain the modern work as well, and is the link between them adequate?

(*Dr Hegarty*) From the Department's point of view, there will clearly be a massive demand to be able to cope with unconventional hybrids, if you like, or genetically manipulated organisms and the impact that they will have on systematics as a whole. So there is a new area that we have got to be able to fund to provide the people who have expertise in dealing with that. Perhaps Dr Ingram would like to come in here. He will argue that equally there is a massive demand for the conventional taxonomy. Vast areas of the world's flora and fauna have not yet been characterised. At the end of the day, one has to balance the demand for systematics against the

demand for plant physiology, for animal physiology and so on. I do not think we would suggest we are wildly out of balance at the moment.

283. Does this start off from the presupposition that there is a fixed envelope of money for these two activities together, and that you must change the balance within them, or is there the possibility that you could increase the amount of money in total because you now have a new and additional area, which you will call "modern methods"? What is the view of the Scottish Office on that proposition?

(*Dr Hegarty*) There is a global fixed envelope available to the Scottish Office which we bid for each year, but obviously every penny that we add within the envelope about which you are speaking means a penny less somewhere else. We have pressing priorities for environmental research, animal welfare research and so on. I would have thought that we were not wildly wrong at the moment. I do not think that message has come through to us. Could I let Dr Ingram in here?

284. In a moment. You are not off the hook. What I am anxious to discover is whether you think that in total the magnitude of resources which is contributed to systematic biological research of all kinds, as you see it, is adequate for the tasks which you have to perform, or whether that is a sum which should increase year by year beyond the inflationary index.

(*Dr Hegarty*) There is an argument that it should increase at least slightly, simply because there is an accumulating job to do. As one adds more information within systematics, as one adds more material, so you have to curate that, so you have a continuing commitment to that. So you could argue that there should be, even to maintain a level effort, a small increment each year. What we have difficulty with at the moment is in defining precisely what we are going to call systematics, particularly in the area of modern systematics. Maybe we have not quite come to terms with the definitions in that area yet, because clearly our funding in molecular biology has increased very considerably over the last five years, and that carries systematics work with it, despite the fact that the people doing that may not call themselves systematists. To be able to answer your question one would need to get one's definitions clear.

285. I did define it by saying "including the modern methods".

(*Dr Hegarty*) I think we have the balance about right at the moment, although we will have to watch very carefully for the future.

286. Are you saying you think that the sum of money is more or less right at the moment and should not be increased beyond the normal inflationary protection, such as it is?

(*Dr Hegarty*) Looking at our own spend on systematics, depending on how you define it —

287. Defining it in my way.

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[Continued

[Chairman *contd.*]

(*Dr Hegarty*) Roughly 20 per cent of our budget on plant research goes into systematics, and that seems like a reasonable figure.

Chairman] I see.

Earl of Cranbrook

288. Can I comment? We have seen so many definitions of systematics and the Scottish Office's is a very good one, and covers a number of things. Its reference system enables scientists to communicate and so on. It seems fundamentally important and it is difficult to provide a balancing act. I wonder, Dr Hegarty, if it really is as fundamental as these words seem to lay out, how you actually weigh it against something which would be in a sense derivative from the base line that systematics provides.

(*Dr Hegarty*) I think we would have to respond to pressures which said that we had got the balance wrong. It is very difficult to say there is an absolute amount which is correct. One way of proceeding is to respond to pressure that says that there is not enough funding going into a particular area. Certainly from the research point of view mainly from the Scottish Crop Research Institute, we do not have that strong pressure saying because of the lack of systematics work, their work is being held up. Dr Ingram will argue that he does not have enough funding, I am quite sure, for the purposes for which he seeks funds but so far as the East Craigs Laboratory is concerned, there is a shoe-string budget for research in systematics there.

289. So the test perhaps, my Lord Chairman, would be the scientists themselves saying, "Look we need to have more systematic knowledge of the organisms we are working on."

(*Dr Hegarty*) To some extent that is accommodated by scientists then doing their own systematics. I think this is particularly true in agricultural research generally where if a block is reached one either looks around to see whether that information is going to be available. If it is not, you start to do it yourself. That has dangers attached to it in that some of it might be done initially even incorrectly but equally I think we have examples, again at the Scottish Crop Research Institute with the collection of virus types which has arisen through the work in biology, where that is now an extremely important collection. They are in the lead in the world in classifying viruses and that arose simply because of the demands of the job that they had been asked to do.

Chairman

290. Would it nevertheless be possible to answer question 1 here, namely what funds etc?

(*Dr Hegarty*) In relation to training alone or research as a whole?

291. Systematic research and/or training at MSc and PhD levels. I got the feeling—

(*Dr Hegarty*) I misunderstood the question on that one.

292. We want to see if, in fact, there are any trends upwards or downwards in the whole area of

expenditure. Is it divided into two parts, research and training?

(*Dr Hegarty*) I thought that was research or training at research or PhD level.

293. Perhaps you could write to us about it.

(*Mr Moore*) I do not know if it is necessary to write, Chairman, because we can, in fact, say that the training at MSc and PhD levels which we directly support is nil. We apply our support through a series of studentships and I should emphasise that the holders of these studentships are selected because of their abilities and achievements and not because of the choice of area that they intend to work in.

294. But after the event you know what areas they are working in?

(*Mr Moore*) Yes, we know what areas they are working in but it so happens that currently the number of people working in that area is none.

295. None?

(*Mr Moore*) None.

296. Does that give you cause for concern?

(*Mr Moore*) It may reflect a theme which I think Dr Hegarty might want to describe as well, which is one I am sure you have heard from other witnesses. There has been a decline in general interest in universities, in traditional systematics at least.

297. Can I rephrase the question. Does that decline of interest in systematics to which you have referred give you cause for concern?

(*Mr Moore*) I think since systematics is of such underlying importance, yes, it must give us cause for concern.

Lord Porter of Luddenham

298. Can we just be clear that there were very few or no actual applications for systematics or were some of them turned down?

(*Mr Moore*) I would imagine there were none or very few, but I am afraid that I do not have the figures.

Earl of Cranbrook

299. Could I ask then whether these studentships are offered *ad hominem*, perhaps a bright person being asked what they would like to do or are you in any sense trying to direct the fields into which these bright people will turn themselves?

(*Mr Moore*) No, it is entirely reactive. We do not attempt to direct student.

Chairman

300. Will you therefore expect to have any new applicants for the new MSc course that is being run between the Royal Botanic Garden and the University of Edinburgh?

(*Mr Moore*) The Department support is based purely on studentships, of course. It is not for a particular course.

301. Yes I know but you are in the interesting position of saving money if nothing else. May I ask Dr Ingram.

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[Continued]

[Chairman *contd.*]

(*Dr Ingram*) Of course the MSc course is not yet in existence. Detailed plans are being developed largely as a result of demand from overseas although there is a perceived need within the United Kingdom for training in systematics, I think because that training is no longer being provided at under graduate level by the universities. The MSc course does not, of course, only relate to the Department of Agriculture and Fisheries activities but to a wide range of scientific activities within the United Kingdom both in nature conservation and in ecology research as well as in agricultural research. I am being rather evasive, not deliberately, on the question about the Scottish Office, but when the course content has been completely finalised and the university have agreed that they also wish to support it, then we shall be approaching a number of organisations including the Scottish Office to ask whether they are willing to provide support for individual students. We believe that there will be applicants if that support is provided.

Lord Walton of Detchant

302. Whether or not the MSc course goes ahead I presume it would be within the powers of the Scottish Office, if they are concerned about the level of research in taxonomy, to identify specific research studentships solely for research in that field. You could do that if you wished. The MRC has done that, for example, in the past in identifying areas in which they would designate studentships.

(*Dr Hegarty*) Yes, it is also within the director's ambit—I include the Regius Keeper there but I am talking generally about it—and he can also use his core funding for studentships if he so desires.

Chairman

303. The impression that we got from MAFF a short time ago—I do not know if you were present—was that they felt they could do all the training they needed in-house, taking what I would put in quotation marks, “ordinary” graduates from biology—that evidently is not the view in Scotland and it is not the case.

(*Dr Hegarty*) We do have a slight difference in that we have Dr Ingram from RBG whose specific purpose is systematics and the furtherance of systematics and I think within the Scottish Office we are very keen that his MSc course is successful because it would appear that given the decline in universities' graduate training, post-graduate opportunity is the one to exploit. I think perhaps it also offers the possibility of producing students with taxonomy plus another skill which is perhaps one of the areas which is going to be required in the future, particularly taxonomy with molecular biology skills or with information technology skills.

304. We can all see the importance you attach to this area of a field which has not been popular.

(*Dr Ingram*) Chairman, may I just add a little to that reply. You asked earlier whether the balance was right between traditional systematics research and the more molecular and information technology approaches to systematic research and indeed between systematic research in general and modern

developments in biology. I would argue very strongly, sir, that the balance is wrong and that, in fact, in universities the baby has been thrown out with the bath water, that systematic research has disappeared almost entirely and we are producing a generation of graduates who not only know no systematics but, indeed, do not know what they do not know so are not in a position even to determine what systematics has to offer them. This is very much true of young molecular biologists. I sit on the Agriculture and Food Research Council Plants and Environments Research Grants Board and I am a member of the governing body of the John Innes Centre for Plant Research Cambridge Laboratory. And in both of those capacities I see a lamentable lack of understanding of the plant kingdom in a general sense amongst molecular biologists who are attempting to do molecular taxonomy. They really do not know who to turn to.

Lord Butterworth

305. This has disappeared at the under-graduate level?

(*Dr Ingram*) This has definitely disappeared at the under-graduate level.

306. Therefore you are having a MSc course because of the gap that occurred in the under-graduate training?

(*Dr Ingram*) I think yes. We are having an MSc course or exploring the possibility of an MSc course because there is a significant demand from overseas for molecular taxonomy and also because we believe that there is an inadequacy in the United Kingdom training as well.

307. What sort of numbers do you anticipate on the MSc course and what proportion of that number are going to be overseas, do you imagine?

(*Dr Ingram*) We would expect the course to have no more than approximately 10 students on it at any one time and we would expect there to be no less than 30 per cent of the students from overseas—and by overseas I mean Europe as well as the rest of the world.

Earl of Selborne

308. It is a strong case for the molecular biologist having a grounding in systematics. But in your written evidence you also make the point that the obverse is possibly true, that the molecular biologist can bring the modern methods to advantage to taxonomy and you say that you do not think it is sensible for an institution such as yours to spend a large amount of capital when it is provided elsewhere. For instance, you referred to John Innes and the Scottish Crops Research Institute. First of all, would you like to comment further on that as to whether you see there being a workable symbiosis bearing in mind that we are talking now about this difficult area of one sort of funding through research councils and another through what is effectively a grant-aided department and also would you like to give some detail as to how these collaborative links with research councils are working.

(*Dr Ingram*) Can I preface any remark by saying that I have been in post for one year only. Can I also

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[Continued]

[Earl of Selborne *contd.*]

say that molecular biology has been very much a part of my background. I am not a taxonomist by background so I come to the discipline from outside as the director of an Institute and one of my objectives is to build bridges within science between different approaches to the subject. That is by way of preface. I do not believe that I have the resources available to me to develop a large molecular taxonomic research laboratory and at the same time maintain a viable base in traditional taxonomy that builds on the research collections of the herbarium and the living collections of the garden. So purely from the point of view of pragmatism I see the best way forward, if I am to develop new technologies, as being through collaboration. I come from a university background where collaboration between departments and institutes is very common. I do not see any difficulty in building the appropriate bridges and developing the appropriate collaborative links. I do not think they have to be only with research institutes. They can be with universities as well and should be and will. I am already at this point making the contacts, putting the people together—because at the end of the day it is people who do science—so that together they can develop common research proposals that have a probability of funding. I do not see the problem of different sources of funding as being a hindrance to this because I believe that the additional funding that will be required will come from research grants—be it from the European Community, from industry, from overseas or wherever. In other words, we are able to contribute expertise in traditional taxonomy. If I can see, for example, that the University of St Andrews is able to contribute expertise in molecular taxonomy, then there is no barrier between scientists in the Royal Botanic Gardens, Edinburgh and the University of St Andrews getting together, putting together a research proposal and submitting that to the appropriate funding agencies for an additional scientist to actually do the bridging work that links the two institutions together.

309. You will have heard Lord Flowers ask questions of Dr Shannon about Kew attracting research council funding for one thing and another. I think your answer suggests in your case in Edinburgh there is no difficulty in putting forward collaborative ventures, for example, with research councils in order to achieve a common goal?

(*Dr Ingram*) So far as the research councils are concerned, I have to test that possibility. Remember I have been in office for only a short time but there has been no tradition of attracting outside research funds for Edinburgh. Most of the funds I have attracted in the last 6 months have been from private charities, notably Sainsbury Family Charities, where there has been great generosity. The NERC is now funding part of our work, but not directly. It is doing so indirectly because our collaboration in this case is with the University of Bristol and with a university in Germany. The money is being channelled to the university rather than through the Royal Botanic Garden, Edinburgh. From my experience with the AFRC I would say that with applications for grants we would have some difficulty in persuading them to make grants directly to us but if our partner were a

university then I do not foresee a problem. So far as the European Community is concerned, however, there is no reason whatsoever why we should not apply directly for direct funding to the Royal Botanic Garden, Edinburgh or the Scottish Crop Research Institute if that were our collaborating body and indeed I have been a member of a European Community committee which has made such grants.

Chairman

310. You may then run into the difficulty of attribution and a corresponding reduction from research council funds which might otherwise have funded you. Do you know about that problem?

(*Dr Ingram*) I have not yet run into that problem.

311. It is something which you should be aware of. Could I follow on from what the Earl of Selborne said because in your own evidence you refer to collaboration and cooperation quite often and you have been stressing the use of collaboration with the universities. What has struck us, I think, or struck at least one member of this Committee, is the extent to which industry benefits from this kind of work. Do you see collaboration with industry or contributions from industry as forwarding work in systematic research?

(*Dr Ingram*) I would like to see that happen. In my previous post as a member of the University of Cambridge my research programme received considerable support from industry, in particular one plant breeding company and one large oil company. I would hope that in the future some of the work of the Royal Botanic Garden in Edinburgh would be funded in that way but not the core programme. I think the core programme is basic scientific research that requires long-term funding. However, there are applied pieces of research that could add on to that core research which could well be funded by industry and also by research councils and so on and I shall be seeking such funds in the future.

312. Now you are a trustee body it would be possible for you to do this and the Department itself would not be concerned.

(*Dr Hegarty*) The Department would not be concerned.

313. It would not affect the magnitude of the grant aid you got from core funding? One is thinking of claw-back.

(*Mr Moore*) The answer is not straightforward. I have to say that all relevant factors would be taken into consideration but there is no formal claw-back mechanism.

Lord Walton of Detchant

314. Can I just take up one point. You mentioned your background in molecular biology and I am now going to be deliberately provocative and use a crude medical analogy. Do you think there is ever going to be a situation arising when DNA fingerprinting is going to make the traditional anatomy redundant?

(*Dr Ingram*) No, I do not think there is. The way I see it molecular approaches to taxonomy add a level of fine tuning that has not previously been available to the traditional taxonomist. I think the future lies

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[Continued]

[Lord Walton of Detchant *contd.*]

in working together. String quartets make great musicians out of four mediocre players and this is my attitude to research. Chairman, we were asked about funding from industry. I wonder if I could just make one point. Tomorrow Mrs Linda Chalker will be launching the Edinburgh Centre for Tropical Forests which is a collaborative venture between the Royal Botanic Garden, Edinburgh, the University of Edinburgh, the Institute of Terrestrial Ecology, Northern Laboratory and finally a commercial consultancy company. The whole purpose of this consortium is to bid for contracts from governments and from industry and wherever in the area of tropical forest research. Our contribution at the Royal Botanic Garden, Edinburgh is in systematic research as related to tropical forestry. We believe that this consortium will be a very powerful one in attracting funding—not core funding but add-on funding.

Chairman

315. If one could just follow that up by your own evidence which we shall deal with which you sent into us. You make a great point there that systematic research requires long-term planning with is at the other end of the time-scale from the user-demand research. How long does it require and how long must you therefore know you have stable funding?

(Dr Ingram) How long is a piece of string, I suppose is the answer to that. I am not being facetious in saying that either. I think different components of systematic research require different periods of time and, of course, it depends on the number of men and women doing the work. A project like our flora of Bhutan project, in hand at the moment, might take a period of 10 or 12 years to complete. With a bigger man or women force it might require half that time. A piece of thorough systematic research on a large plant group of great complexity like the Umbelliferae, which we are considering at the moment, again might take a period of 10 or 15 years or more unless a very large team were to do the work. But I think one cannot see it in bite-size chunks of this kind. One has to see the slow build-up of knowledge over a period of time. In other words, to conceive and do the taxonomy of the Umbelliferae bang, bang, bang, in a very short period of time is a very foolish approach to the problem because ideas mature over a period. It would be better to be working on two or three groups together and slowly allowing the ideas to evolve. I have gone on a long time. The short answer to your question is I think 10 years of stability is in the first instance required for proper planning of taxonomy research but we would have, of course, reviews year by year as we went along.

316. Perhaps we could ask you a general question about the United Kingdom if that would be in order from your point of view, standing where you do in Scotland and looking at the overview of the United Kingdom. Some people have represented to us the collections which we have—animal and plant kingdom—are of such international importance that perhaps we have a special responsibility for developing them, for carrying them on and for doing research on them. Yet, another comment would be that because they are of international importance

perhaps the international community should pay something towards the maintenance and the research on them. Do you have any view on that as seen from your Scottish view point?

(Dr Ingram) Do you wish the Scottish Office to answer this or me?

317. Any of you as we are anxious to get the answer.

(Dr Ingram) I believe that the collection in Edinburgh of preserved plant material and of living plant material is of great international importance and is part of our national heritage. However, because of accidents of history, these collections have been amassed in Edinburgh just as they have in Kew and the British Museum and we have an international responsibility to curate them properly and that curation must require research as well. I think many of the benefits of these collections accrue not to the developed countries but to the less developed countries who are not necessarily in a position to fund the kind of research that we do. Having said all that, I would hope, yes, that international funding and add-on funding would come in to support our work and again this is what the Edinburgh Centre of Tropical Forests is all about—attracting that international funding whether it be from industry or from governments.

318. What goes for Scotland goes for the United Kingdom generally?

(Dr Ingram) I think it does—well, I do not think, I know it does.

(Dr Hegarty) Our other interests are in working collections associated with the research that has been carried out and those are rather different. The Commonwealth potato collection, which has got international value, status, recognition, is not actually a very special collection of potatoes. It is special because it has got a very high health status and therefore it is immediately useable in breeding programmes and so on and similarly the Scottish Crop Research Institute's collection of various soft fruit, again, are only important really because of the high health status that they have. From that point of view I think one would not necessarily expect international funding coming in for those. They really are working collections which are borne on the cost of the research that is carrying on. The larger collections which are of world importance I would have thought must ultimately be funded internationally.

(Dr Ingram) May I add one further thing, Chairman. I have recently been travelling in China and the collections of the Royal Botanic Garden, Edinburgh are particularly pertinent to China.

319. So many Scottish missionaries!

(Dr Ingram) Of course and we have to thank them and the Scottish botanists as well, who spent their lives in China. But there are Chinese scientists who are desperate to come and work on our collections. They could not fund that work themselves. That funding can only come from other sources and the same applies to our work in Brazil and so on.

320. And obviously Bhutan?

(Dr Ingram) Most definitely in Bhutan, yes.

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[Continued

[Chairman *contd.*]

321. We are running a little bit overtime but could I raise one point which is your final point in your evidence which is the comparison between the United Kingdom and the USA particularly in having centres of excellence and strong cooperation between the universities and the museums. You refer to Harvard, Missouri Universities. Are there any lessons we can learn from that? Should we be following that path?

(*Dr Hegarty*) That is interesting because 10 years ago in Edinburgh we had something when not very different from that Professor Davis of Edinburgh University was actually accommodated within the Edinburgh Garden for his work. Since that time—unfortunately, after his retiral—there has been some separation between the two organisations and of course at the same time work on taxonomy has become rather less significant at Edinburgh University. So the hope to create the sort of ambience, if you like, one sees in America could be very difficult and it might not be productive to try and do that. I think the alternative approach, which we were talking about earlier, which is a networking approach to use a modern term for it and the sort of approach that Dr Ingram was describing, would be the other way forward. That is to develop the links which allow the feeding of expertise in both directions. That is the important thing. We have been concerned recently with one institute in Scotland, which we have not talked about at all, which has got a job which is dependent for its success on

collaboration, and orchestrated collaboration simply cannot work. I think that is something one finds very quickly. It has to be the motivation of both parties being able to get something out of it. That is why in answer to your question about whether the main constraint is just funding, I am quite sure it is not just funding. It is the time it takes people to understand that they have something to gain from each other and the change of attitude which encourages that. It may even be that funding could be really quite a minor constraint, when people see they can start working together for mutual benefit.

322. This of course presumes you have an adequate supply of people interested in this field?

(*Dr Hegarty*) That is correct.

(*Dr Ingram*) Chairman, can I just add a slight gloss to that. The University of Edinburgh Chair of Botany and the Regius Keepership of the Royal Botanic Garden were one post originally. They were divided and then there was the Davis unit later. In the year I have been there the links with the University of Edinburgh have strengthened. The MSc course is a demonstration of that. We will have the links between the Royal Botanic Garden and the universities of Scotland in both in teaching and in research within five years. I can promise you that.

Chairman] Thank you very much indeed for coming and giving very interesting evidence.

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MINUTES OF EVIDENCE

TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 14 May 1991

ROYAL BOTANIC GARDENS

Professor G T Prance and Professor G L Lucas

*Ordered by The House of Lords to be printed
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TUESDAY 14 MAY 1991

Present:

Adrian L.(Chairman)
Flowers L.
Nicol B.
Porter of Luddenham L.

Taylor of Blackburn L.
Whaddon L.

Memorandum by Royal Botanic Gardens, Kew

1. What is the utility of systematic biology research?

a. Systematic biology is fundamental to all biological research. It provides the philosophical and nomenclatural framework for all biological research and for all users of organisms. Agriculture, forestry, land utilisation and conservation programmes all depend upon an accurate and stable way of naming, relating and identifying organisms whether they be useful crops or pests.

b. Systematic biology encompasses *taxonomy* (the science of classification), *nomenclature* (the rules and guideline for naming organisms) and *evolutionary theory* (the philosophical basis for interpreting the pattern and mode of phylogenetic relationships). Modern systematic biology is a *synthesizing discipline* drawing on data from many other sources and areas of scientific study.

c. The accurate delimitation of species can often be a matter of life and death. Bad taxonomy, or inaccurate identification of poisonous or pestilent organisms, can result in widespread deaths, stock losses, crop failures, costly ineffective control programmes, etc, for example:

- ergot disease
- AIDS
- algal blooms
- wheat rusts
- noxious weeds (often comprising—hybrid species complexes with differential response to chemical and biological control)
- variable causal agents of disease eg. malarial strains, hepatitis

d. *Predictability*. Systematic studies enable us through the classification of organisms, organs and organelles, using homology, to make predictions about an organism and its relationship to other organisms. Two examples serve to illustrate this (a) the hydroxyl alkaloid castanospermine, found in an Australian tree, *Castanospermum australe*, has proved efficacious in interfering with the metabolism of the AIDS virus. A taxonomic review of the genus showed that its closest relative is a South American genus *Aleax*, that was later found to be congeneric. *Aleax* also contains the alkaloid as well as a few less-toxic chemical analogues. This would never have been discovered without the taxonomic framework (b) looking for appropriate species of rattan for introduction to plantations, we can narrow the field down from the 600 known species by selecting only those species related to species known to be of good quality and growth form suitable for growing.

e. *Repositories of preserved organisms*. The millions of preserved organisms housed in thousands of museums world-wide are a major source of geographical, ecological, biological, and, with new technologies even genetic information about extant and extinct organisms. The existence of these collections allows us:

- (i) to study the distribution, variation, and evolution of organisms;
- (ii) to study the ways in which organisms can be used. For example, there are many data about medicinal, culinary and other uses of plants on the labels of herbarium specimens;
- (iii) to postulate why some groups of organisms are or were evolutionarily more successful than others;
- (iv) to reconstruct past climates and so enable us to model the effects of local and global climatic change, past and present;
- (v) to discover new sources of minerals, diatomaceous earths, fossil deposits, oil, rare metals, etc;
- (vi) to have a reference source for forensic science (e.g. algal, fungal and bacterial spores and pollen) and for many other practical applications such as the identification of hayfever causing pollen.

f. *Stability in the use of scientific names* is one of the major goals of systematics. Scientific names are the key to accessing all published information about a particular organism. By cataloguing all the names of published organisms, then matching these against preserved materials, paintings, etc, taxonomists ensure that all the information published about any particular species can be gathered together to provide the fullest possible basis for further study of that species. It also provides the baseline against which to judge whether new collections coming out of unexplored regions are new to science or not.

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[Continued]

g. Accurate taxonomy is essential where there is legislation to control the use of or import and export of species. For example, the CITES convention depends on accurate species identification to control trade of living organisms. There are many regulatory provisions for narcotic plants and fungi where species identification is essential.

h. The inventory of the world's flora is far from complete. Each year over two thousand new species of higher plants are described. Table 1 shows the consistency of these new discoveries by showing recent data from the *Index Kewensis* that compiles data on all new plant names, on a worldwide basis and is a basic tool of all plant systematics.

TABLE 1

Data from *Index Kewensis* about new species of seed plants and ferns described between 1986 and 1990.

		1986	1987	1988	1989	1990	Total
Seed Plants	New genera	114	95	89	98	91	487
	New species	2,832	2,526	2,859	2,752	2,635	13,604
Ferns	New genera	5	3	3	1	1	13
	New species	238	142	159	170	116	825

Further botanical systematics and inventory are obviously needed at a time when 13,604 new species of flowering plants have been discovered in only a five year period. The inventory is far from complete.

2. Does the need to specify particular organisms in connection with eg. intellectual property rights, regulatory provisions etc, impinge upon your work?

a. At Kew we are screening plants for their medicinal and insecticidal properties, in collaboration with pharmaceutical companies and British Technology Group. Should patentable products emerge the question of intellectual property rights will certainly arise. We are concerned that if marketable products are discovered from plants collected in countries of the developing world that they too benefit from royalties generated by the commercialisation of germplasm.

b. The new emphasis on molecular systematics is beginning to revolutionise our understanding of relationships and evolution of organisms. The implications of this research are profound. Inter alia, they:

- could be the basis for successful lawsuits and paternity cases, unravelling smuggling routes and origins (especially of rare and endangered species, natural drugs, etc.).
- provide measures of genetic heterozygosity in natural and captive populations of plants and animals that will give a more rational basis for selection for breeding; capture for domestication; conservation in genebanks; re-introduction into the wild; incorporation of new attributes into existing domesticates; and allowing monitoring of genetic erosion in natural and domesticated populations; etc.
- the question of intellectual property rights is going to become particularly troublesome as molecular systematic techniques improve because as it becomes easier to fingerprint organisms and even individuals in different species so will the pressures increase to patent organisms, particularly genetically engineered transgenic hybrids or even transfamilial and interkingdom "creations". There is already evidence that as non-taxonomists are increasingly generating the new "organisms" or are uncritically accepting their finger-printing as inviolate that they could run into serious difficulties that only the techniques of systematics could help unravel (eg. questions of convergence, parallelism, reversals, non-homologies, etc.).

3. Is the level of United Kingdom research appropriate? If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?

The level of United Kingdom research in systematics has gradually been eroded in favour of more experimental disciplines to the detriment of all biology. This has been a trend in the USA, EEC countries and elsewhere.

at Kew we have resorted to much time-consuming fund raising to accomplish our mission in systematics which would certainly indicate that current support is insufficient. Other areas of biological research have been considered more fashionable, but in the long term they could be of limited significance in comparison to the need for an ongoing stable system of classification. The failure to support systematics adequately will eventually have a knock-on effect on the research of other scientists, industry and on the international prestige of the United Kingdom.

The new tropical forest initiatives will founder because existing systematists are already overcommitted and will be unable to name the collections that will underpin all the new studies in the tropics. Inadequate biodiversity databases will surely hamper these projects from achieving their full potential. This work will go to other countries, with all its advantages, or in some instances will remain uncompleted.

Even in the more fashionable aspects of systematics the United Kingdom is lagging behind. The 1990 meeting of the American Institute of Biological Sciences contained a very large number of papers on molecular systematics and reflected that United Kingdom research is at a disadvantage in this critical area.

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Although basic systematics research does not translate directly into industrial, pharmaceutical and agricultural application it does so indirectly because such studies are precursors to application. Britain's competitive edge in biotechnology may be becoming eroded. The "lag time" could quickly develop into a permanent lag which might not be bridged.

At Kew we are grateful for government support that is enabling us to build an extension to our Jodrell Laboratory which will more than double our space for experimental research. It includes space for molecular systematics. We are worried about the lack of funds to employ molecular biologists and to supply them with materials and equipment.

However, our main concern is the need to strengthen the funding of more traditional systematics upon which so much depends.

The vital importance of systematic biology in the race to conserve the world's genetic diversity for future generations cannot be over-emphasized. Much greater resources need to be mobilized to this end; systematic biology has done extremely badly compared to other fields of biology at the level of university research and the production of biologists with even adequate training in the field. As a consequence new taxonomic appointments are often filled by applicants from outside the United Kingdom.

The Royal Botanic Gardens, Kew recently hosted an international meeting to discuss the need for a world checklist of plant species (*Species Plantarum*). Because of its premier role in plant taxonomy and cupitation of data, Kew was offered the opportunity to be the site of the secretariat rather than one of the seven other foreign museums and gardens that formed the steering committee for the project. The *Species Plantarum* project will bring status to systematics in the United Kingdom, but we are seriously considering whether or not we can afford to undertake such a project at a time of diminishing funding for systematics!

4. Is the United Kingdom research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate, e.g., importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available.

a. Despite the budgetary constraints and shortages of personnel, the United Kingdom contribution to systematic biology research is very significant and wide-ranging. However, there is a need for greater co-ordination between institutes, both within United Kingdom and more particularly, within the EC. There is a need for a Europe-wide strategy, within which the United Kingdom should be able to concentrate on particular strengths, in collaboration with other European institutes wherever appropriate.

This strategy should be organised on both *regional lines* (which tropical countries to target?) and *systematic lines* (which are the most important plant families?).

Collaboration with and support for biologists and their institutes in tropical countries and advanced training of their graduates and post-graduates in a most important objective for such a strategy.

The Royal Botanic Gardens, Kew makes every effort possible to coordinate its research, inventory and collection policy with that of other national and foreign institutions. The '*Morton Agreement*' exists between the Natural History Museum and Kew to divide collections and research both systematically (e.g. Fungi and ferns at Kew and Bryophytes and algae at NHM) and geographically (e.g. Europe, North and Central America at NHM, South America and Africa at Kew). The Keepers of the herbaria of Kew, RBG Edinburgh and the Natural History Museum meet annually to ensure a united policy.

b. Within the United Kingdom there needs to be closer liaison between universities and "biodiversity institutions" (Botanic Gardens and Natural History Museums), both at the research and postgraduate training level. The depth of expertise at these centres, both intellectually and in experience is higher in the biodiversity institutes. One need only look at the level of publications, influential books and conference proceedings, that are produced by these institutes. They also have the advantage of being able to tackle long term projects. Many systematic problems cannot be tackled within a three year period and require an extended commitment with stable funding.

The contribution of biodiversity institutes in training postgraduate students in systematics is significant and has been underrated. Most students would not be able to complete their studies if it were not for the access they have to the facilities, libraries and collections of such institutes. Closures or reduced financial support will have indirect and direct effects. As less areas of expertise are researched fewer foreign students will be attracted to the country, decreasing university revenue, but more important to long term science in this country, reduce the importance of foreign students as foci for the international career development of United Kingdom scientists and the building up of personal research networks.

Perhaps scientists working in the biodiversity institutions should play a more active role in university and polytechnic postgraduate teaching by providing national specialist courses in areas of expertise unavailable in the teaching institutions.

Scientists at Kew and other biodiversity institutions already play a critical rôle in the examining of masters and doctoral theses for British and overseas universities. They are also essential in referring grant proposals of the U.S. National Science Foundation and of other countries, all of which adds to the United Kingdom's

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prestige and is a reflection of our international importance in systematics. The shortage of systematists means that more and more of this work is going to fewer people.

Perhaps Research Councils should recognise the existing training role of biodiversity institutes and support them (currently they tax them in the rules for CASE awards).

c. Most of the systematic research in the United Kingdom is devoted to floristic research of extra-European countries. This is partly a legacy of a colonial heritage and the rich holdings of biological collections gathered at that time (often still the only collections for many such countries) but in recent times is also tied into the needs of a range of development projects in developing countries (mostly sponsored by ODA and NGO organizations). The future of systematic research in the United Kingdom will almost certainly reflect in part the needs of foreign policy, particularly concerning development aid and the attendant shift in emphasis to sustainable development, the increased need for economic botany information and finally access to sources of new raw materials for industry and markets for the country's manufactured products. Recent concerns on global warming, acid rain and other environmental issues that have begun to whittle away the ability of individual countries to determine independent research policies are also starting to affect the nature of the systematic research undertaken in the United Kingdom.

The nature of funding, and the increasing reliance on private foundations and soft money research with short-term, often ad hoc, research goals are also bringing new pressures to bear on the teaching and research prospects in systematics.

To answer the question as to whether systematic research in the United Kingdom is in the right areas, one has to define and analyse the broader social and political milieu at national, pan-European and global levels. For example, new European political initiatives and enactments in 1992 could have a dramatic effect on the availability and competitiveness of jobs in systematics in Europe and on the mobility of systematists within Europe. If the mix is wrong in the United Kingdom then other centres within the community will fill in the gaps, or begin to develop into centres of excellence that could even undermine traditional strengths in this country. The one advantage that used to accrue in the United Kingdom, tuition in English, is increasingly, with the adoption of English as an international lingua franca, less important in guaranteeing that foreign and local students will study in the United Kingdom. Currently the EC has no programmes in whole-plant systematics.

Guiding principles that would ensure British systematics becomes relevant for the nineties might be;

i. The funding of subdisciplines within systematics or of specialist taxonomic groups. The continuance or relegation of these should be determined by national needs and not by the financial constraints or unilateral decisions of individual institutions.

ii. Funding should become available for specialised training in systematics that maximises the most effective use of expertise and teaching quality. Such courses could be given either in selected universities or at biodiversity research centres. Funding should be made available for master and doctoral students to attend these courses as part of their training.

iii. Central Government science funding should be restructured so that biological research funding is separated from general science funding. A Biodiversity Research Council, with representatives from biodiversity Institutes. Universities, NGOs and other user groups could be set up to rationalize spending on systematic, biological and conservation research.

iv. Priority areas of research should be determined at two levels: firstly, immediate, medium and long term research within the United Kingdom, and secondly, stable long term global research mainly at monographic level.

v. Support should be given for funding the development of "generic" software that will be of use to taxonomists everywhere and not just restricted to the interests of a particular institute. Software development costs could be shared on a pro rata basis by all major biodiversity centres or via special private and or public funding.

Software projects that need special attention or improved support include:

- (1) Herbarium management systems
- (2) Taxon databases
- (3) Specimen databases
- (4) International standards; esp. Data transfer formats and communication formats.
- (5) Distribution mapping
- (6) Expert systems of the International codes of Nomenclature
- (7) Description writing and key-making
- (8) Video floras: relational databases linked to expert systems and graphical libraries
- (9) Phlogenetic analysis software

5. What is the extent of our need for reference collections including foreign material (type collections, living culture collections etc) as a basis for systematic research? Is provision for their storage and their

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curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?

One of the great strengths of biodiversity expertise in the United Kingdom is the unsurpassed breadth of coverage of the world's biota that the country's museums contain. The general level of curation and quantity of nomenclaturally important type material is very high. These two features set the United Kingdom's Biodiversity Centres apart from those of most other countries. It allows us to conduct a breadth of research few other countries can match. The herbarium of the Royal Botanic Gardens, Kew is one of the largest in the world, contains more type specimens than any other and is consulted on a daily basis by scientists from around the world.

- Research collections are fundamental; systematic biology research cannot be carried out without them, nor are the collections of much value unless they are properly curated. A huge but badly curated herbarium is as about as much use as a library which has all its books strewn over the floor.
- United Kingdom has a major responsibility to maintain its systematic collections in good order as a global resource base. Biologists from all over the world are constantly using our collections. The importance of our collections is a direct heritage from the empire, which provided the basis for their global scope and for the breadth of United Kingdom research based thereupon.
- Expansion space for new collections is badly needed. The growth of tropical research is constantly increasing the flow of collected material. Tropical institutes routinely deposit duplicate material in United Kingdom as a safeguard against possible loss of material in the country of origin. If these collections were returned to their countries of origin they might or might not survive depending on the infrastructure and available curatorial expertise. They are too important historically and scientifically to even consider disposing of.

For further information see Appendix A: From *Nature* Vol. 347—20 September 1990.

6. What new methods are there and how will this affect United Kingdom research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is United Kingdom research taking cognizance of the full range of new developments in this field.

Systematics world-wide is coming into its own again as the broader community becomes aware of the magnitude of the loss of species around the globe. The spiralling population of the world and its attendant environmental destruction or overexploitation, is also creating demands for more information about pests, economic plants and animals, and micro-organisms. At the same time there have been some remarkable advances in molecular biology, in our understanding of the basis of evolution and in the theory, design and implementation of information technology, that have enabled systematists to ask new questions and work in ways which would have been impossible a decade ago. United Kingdom scientists are in the forefront of some of these technical and intellectual advances, but it is an ageing generation and there is an urgent need to sponsor these new research areas further. However, as stated previously this should not be done to the detriment of collections and collections based research that underpin all later research developments.

Information technology has not yet been sufficiently applied in systematic biology institutes, mainly because of the large investment in manpower and funds necessary to produce a useful result. However, this is an important priority if the full potential of the existing, non-computerized database of information is to be realized.

The two main areas of applications are:

- (i) databasing of reference collections.
- (ii) analytical methods: cladistic, phenetic, mapping (Geographical Information Systems).

Systematics in the United Kingdom is dropping behind other countries because of our lack of resources to apply adequate information technology and large analytical methods such as Geographical Information Systems.

7. Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure?

Systematic research requires collections—these are safest in major institutions—University reference collections are at the whim of the current head of department who may have no sympathy with systematics—we have seen again and again the disbanding of collections. The major collections must have a secure funding base. At present their funding base is not secure.

Retrenchment, shifts to trendy areas, loss to management of a generation of productive researchers, non-replacement of retired scientists and resignations from the profession are undermining the whole age class structure of active systematics in the United Kingdom. In some areas of expertise there are gaps which will take years to fill and some which are probable irreversible. Unless this problem is evaluated in some depth it could become the achilles heel of British systematics.

8. If research is to be continued who pays? Should burdens of expense be shared with other countries, eg a United Nations programme? Can ESF help to rationalise activities?

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Within United Kingdom, how much more should government pay for and how best can budgets be protected?

What role can industry play?

Basic core work should be government-funded with some sort of guarantee of continuity. United Nations could play a role in funding, but I would question the spending of United Nations funds in Britain when there are urgent needs in the developing world for safeguarding and developing systematics which should have priority over United Kingdom. United Nations funding would be appropriate for collaborative projects especially in the field of biodiversity inventory and the training of developing world personnel, and the proper curating of developing world herbaria.

United Kingdom government does need to invest more in systematic research—at least the three major systematic institutions (Royal Botanic Gardens, Kew; Natural History Museum; International Mycological Institute) should be able to function properly without major financial constraint and four or five universities should be supported to develop active systematic teaching programmes.

We are seeing the beginning of a small amount of sponsorship of systematics research by industry—if we do not receive all the funding we need from government then industrial sponsorship may help, but this requires much time to be diverted from research into fund-raising activities.

Industry could pay commercial rates for the services it receives. It could fund research areas that are certain to provide commercial advantage to the country and claim Government rebates for successful partnership developments arising from such research.

9. Is teaching adequate?

No. This is partly a problem of the lack of employment opportunities in systematics in the United Kingdom, the extremely poor funding support for taxonomists in Universities, the non-proactive nature of systematics, and the lack of an effective systematics lobby in the universities and research councils. The standard of postgraduate supervision in some universities, particularly of foreign students, is not a credit to the United Kingdom systematic community. It has also in recent years placed a hidden heavy burden on the biodiversity institutes. There is much to suggest that there is an acute shortage of plant taxonomists in the United Kingdom—we have appointed several foreign nationals to posts at Kew recently—United Kingdom applicants have been few in number and not good enough. British universities are just not turning out suitable people. We are also receiving more and more requests for assistance in providing the systematic base for aid projects, etc.—and yet we have insufficient manpower to provide this back up. If we had the resources we could go out and hire—but increasingly we find there are few suitable candidates available.

Even postgraduates who have been trained in taxonomy have inadequate backgrounds in essential, but “traditional” areas such as plant morphology. Skill in languages is essential for a good training; a reading knowledge of German, French and Latin is necessary for botanists, otherwise a large part of the most important literature is inaccessible.

10. What can we learn from abroad, especially the USA?

Europe, rather than US, is where we should look first. There are enormous resources to be tapped, and the political and economic context should be more favourable. Other European countries are very active in tropical fieldwork and collaboration; Scandinavian and German universities still produce well-trained taxonomists; France has excellent modern research centres in plant morphology and tropical forest studies; new software is actively being developed in various European centres; Spain is emerging as a strong centre for traditional systematic teaching largely as a result of British influence and teaching of a core generation of their leading young teachers and researchers; to mention only a few points. As a whole, the herbarium resources of Europe are at least as great as those of the US and certainly more important historically. Tropical forestry and associated forest botany has a long and excellent tradition in the Netherlands.

Outside Europe, Australia and South Africa have advanced approaches to floristic studies and much of what they have achieved could be applied here too.

In the USA in recent years there has been a turn around in the emphasis and direction of systematic research that was determined largely by a shift in the methodology and philosophy of classification that resulted in the ascendancy of phylogenetic systematics over phenetic taxonomy and traditional systematics. The coincidence of this approach with major breakthroughs in molecular genetics and the concordance of interest of these two groups, coupled with the increased influence of NSF (National Science Foundation) funding, has seen a radical shift in direction of systematic research in the USA. The emerging field of molecular systematics competes strongly with traditional systematics in the USA for mainline funding. One fall-out from this is the parallel emergence of a biodiversity illiterate and biologically naive crop of new scientists. However, there are also a few quite outstanding individuals of that generation who are advancing systematics in a major way. The impact of this new trend is increasingly leading to systematics being unable to provide the broad range of essentially low cost services that traditional systematics provides to the community. Greater emphasis on these new trends is needed in the United Kingdom but not at the expense of the less appealing areas of

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systematics such as basic inventory, nomenclature, monographic and cytogenetic studies and floristic writing. The new tools are wonderful for solving certain types of problems but are not panaceas for all systematic problems. In many instances basic comparative morphology is faster, cheaper and not bettered by more labour intensive and costly techniques. The fact that the new trends in the USA are more evident than in the United Kingdom allows us the opportunity of judging their impact on the wider and the scientific community over there. And this we should monitor.

Basic systematics in the USA receives much support from the National Science Foundation that has a Biological Resources Department that provides grants to the major Museums and Botanic Gardens that hold collections of biodiversity. The NSF also supports basic monographic and floristic work in a way that is not available in the United Kingdom. Some sort of competition grant system that is open to United Kingdom systematics would be a great boost to the field.

Finally the committee should be made aware of a forthcoming meeting of The Linnean Society of London and the Systematics Association which was developed because of our concern about the current state of systematics in the United Kingdom. The meeting entitled "Taxonomic Research and its Applications: Problems and Priorities—An Appraisal of Taxonomy in the 1990s" will take place at the Royal Society on Tuesday 11th July 1991.

In summary, we propose that the Committee consider:

1. The hidden but positive focal role systematics plays in science and industry in the United Kingdom.
2. The world heritage status of our taxonomic collections.
3. The considerable influence British systematics has worldwide even though the taxonomic community is small. This is especially so in pioneering new methods, etc.
4. The ageing population of British taxonomists and the decline in teaching standards and post graduate supervision.
5. The insecure funding base for systematics.
6. And finally that systematics in the United Kingdom have put their house in order and have clear practical visions about the future but now need positive response from Government to achieve them.

Never let it be said that the great biodiversity institutions of the United Kingdom retrenched during the period of greatest extinction of living organisms in any single period of earth's history!

APPENDIX A

In defence of Taxonomy

In *Nature* of 16 August (Vol. 346, 602; 1990), H. T. Clifford, R. W. Rogers and M. E. Dettmann argued that taxonomists might usefully dispense with the existing massive herbarium collections. We have received many letters criticising this view. Here we publish those received first; the remainder make many of the points below.

SIR—Clifford, Rogers and Dettmann have exaggerated the problems faced by taxonomic institutes and have misunderstood the role of herbaria. They suggest a solution that displays ignorance and a surprising lack of understanding in professional biologists.

The worry is that their solution may appeal to the uninitiated, and could be taken up by busy administrators and politicians seeking quick remedies to immediate ills. As representatives of the systematic botany community in Australia, we would like to stress that systematics is not merely an exercise in stamp collecting or a naming service for other branches of biology.

Briefly, Clifford *et al.* state that herbaria are becoming choked by ever-increasing numbers of specimens, most of which, in their opinion, have so little value that we would be better off without them; they should, the authors say, be pulped. The principle can be applied to all taxonomic collections. With touching optimism, they go on to suggest that funds and staff-time so saved would be diverted to "taxonomic research proper".

No part of Australia's flora is well known *in toto*, but we probably all know of individual species that are so well-represented that some specimens could be pruned without loss. But even if a specialist were to prune, the saving in curatorial load would be negligible. All the institutes we represent already practise some pruning and quality control of incoming material; some reserve sterile material apart until after publication of results, and disposal seems appropriate. But no case at all can be made for ditching the bulk of the collections.

The lack of understanding of the difference between written records and specimens shown by Clifford *et al.* is little short of stupefying. A description makes accessible a selection, a subset, of the total information that a specimen yields. There is no such thing as a complete description; there will be as many descriptions as there are disciplines studying that specimen, and many of them will not overlap. Yesterday we would have had

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descriptions of gross morphology, anatomy and palynology. Today, we have electron microscopy and biochemistry in many new and revealing facets. Tomorrow, who knows? No specimens, no information.

Today, systematic biology is being rejuvenated by new and more disciplined ways of thinking; the computer provides powerful new tools and the predictive power of the resulting classifications—the central aim of the systematist—improved without specimens, variation cannot be assessed. The amassed collections of ourselves and our forebears now have new potential in the urgent task of discovering, describing, naming and above all understanding the relationships and biology of the riot of life around us while it lasts. It is time to build on the resources of our collections, not to discard then untapped.

Finally, the authors confuse herbaria (the collection of dried plant specimens) with Herbaria (the institutes that care for and use them). The value and usefulness of herbaria are judged by the number of specimens, the geographical areas covered, the groups represented, the state of their curation and the proportion of 'classical' material mentioned in the literature, including types. But Herbaria are indeed judged in part by the quality of their research, in part by their attitude and accessibility to visiting researchers. The quality of the research is a much more complex mix of factors than Clifford *et al.* allow—published floras, monographs and papers in the scientific literature are the most obvious, but accuracy in the identification of collections derives in large part from long familiarity with the collections. In turn, these identifications are the key to the literature and are thus of crucial importance to all those other disciplines that rely on taxonomists' insight and experience.

It is to be hoped that those concerned with support and management of our biological collections are not misled by the simplistic, short-sighted and ill-conceived ideas put forward by Clifford *et al.* Comprehensive, well-curated collections are essential for the production of high-quality systematic research sought by these authors.

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SIR—Clifford *et al.* raise some interesting points concerning housing collections in the natural sciences. But I will not be jettisoning any part of our herbarium.

First, plants, unlike chemical compounds, are much more complex subjects where any current description interprets only x out of n characteristics. Experience shows that the next investigator will want to see all the available material, not just an historical account.

Second, we keep well-documented specimens, as well as type(s), because the originally described material may not adequately show the range of variation in species (super-orders are too coarse a taxonomic category) and may not reflect the changing distribution of species.

Finally, reference material is needed to identify enquiries and for educational purposes, and specimens are both historically interesting and aesthetically pleasing.

At a time when many institutions in the public sector are under pressure to provide short-term solutions to cash problems, it is tempting to cast doubt on long-term scientific objectives and commitments to material culture. But with most of the world's species still to be documented, this is no time to weaken our resolve. Rather, natural scientists should focus their skills and what resources they have left in overcoming the mid-term blues. This could start with a look at collecting policies and regional needs.

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SIR—The taxonomic Brave New World outlined by Clifford *et al.* is strange indeed: natural history collections, they say, are not needed because chemists do not store the compounds they synthesise; taxonomy should be based on descriptions and type specimens and should have a rational economic basis.

But one cannot synthesise individuals as a chemist synthesises compounds. A chemical compound and a herbarium sheet are not comparable entities, as philosophers of science have long acknowledged. To say they differ in degree, not nature, simply will not do.

Descriptions alone, even when accompanied by type specimens, are no basis for the comparative biology of the future. For one thing, descriptions are often poor representations of what is described—and, in this area, taxonomists need to progress. And taxonomists make mistakes.

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By way of illustration, species limits now need extensive change in a phylogenetically critical group related to the mangosteen (*Garcinia mangostana*), found from the Philippines to New Caledonia. I know this only because I have access to collections assembled at great cost over 250 years; the descriptions are of little help, but the specimens, and some new characters, are.

Knowledge of plants in the field is important, but well-maintained herbarium collections contain a mine of information. Future monographers are likely to rely more, rather than less, on herbarium collections for an understanding of some aspects of variation patterns. These collections will more and more represent populations that have become extinct because of man's activities.

It is ironic that a photograph of Kew Herbarium should accompany the article by Clifford *et al.* Almost 100 years ago, a director of Kew, W. T. Thistleton-Dyer, suggested a similar course of action to the one they propose. He accepted variation, but thought only a single specimen of each species, representing the typical morphology of the species, was needed in the herbarium. A number of 'duplicates' were removed from the collection at Kew, and some sent to Berlin—where they were described as new species (B. Verdcourt, personal communication).

Natural history collections are a celebration of diversity, right down to the level below the species, but Clifford *et al.* rightly ask whether we need all the collections. Problems attendant on the storage of voucher specimens are real. Clifford *et al.* might also have noted that many duplicates of one genotype may be taken from a single tree, and that 20 duplicates housed in as many herbaria might be excessive, useful though they may be in evaluating variability.

One wonders if the general solution proposed by Clifford *et al.* is a justification for cutting down on herbarium activities in a particular university department; a rationalization after an all-too-common academic tragedy. Being associated both with a large herbarium and a university department, I believe that rather different kinds of research may be appropriate for the two. But the proposals made by Clifford *et al.* will help neither academic institutions nor the herbaria; taxonomy must first have a rational *scientific* basis, and to destroy the collections will not provide this.

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Sir—I was surprised that three biologists, no doubt experts in their own fields, should appear to have such naive views about the value and methodology of basic taxonomy as to suggest that our collections should be turned over to the garbage collectors. Even a superficial consideration reveals that their suggestion is completely counter to the rigorous methods entailed in scientific research, which should ensure that results are based on repeatable analyses of natural phenomena.

Clifford *et al.* say "Biological specimens may be different from [chemical specimens], but they differ only in degree not in kind". A chemical element or compound can be rigidly defined and shows variation only within certain repeatable limits, whereas a biological species is of necessity defined according to one type specimen of a species, a species being composed of many individuals showing a range of variation. It is impossible to express the nature and extent of this variation in its entirety and it is therefore necessary to sample it and to keep material for research. Chemicals do not reproduce, neither do they pass on heritable characteristics to their offspring. The destruction of herbarium material, as suggested in the Commentary, would ensure that no one could then verify or refute results which did not appear to agree with the main body of data about, say, a species.

One of the more grotesque suggestions of Clifford *et al.* is that decisions on taxonomic changes should be based solely on published descriptions. Perhaps the best way to show the fallacy of their argument is to consider one particular case.

Epling prepared a revision of the genus *Eriope* from South America in 1936. He was a careful and productive worker, but in this case his research had many defects. He recognized 21 species. If all the material had subsequently been destroyed, I would not have been able to revise the genus, finding that one species had been misinterpreted and belonged to another genus and another had been misinterpreted and belonged to a different family. Of the remaining nineteen, one was better placed in a separate genus, due to characters which Epling had failed to observe, and a further six I was able to reject as one species, as the result of careful analysis of the range in variation of the other material of these taxa available in the form of herbarium data, which Clifford *et al.* would have pulped. I also described a further three new species using material sent to me by other herbaria.

My publication on this topic, which included distribution maps to show bio-geographical patterns, would have been impossible without all the herbarium material at my disposal, including not only new but also re-identified materials wrongly assigned by Epling.

As a result of my studies on *Eriope* and related genera, I was able to regroup the taxa into genera that more closely reflected their natural relationships. Nevertheless, my field work has also shown me that I am not

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infallible. but that some opinions I held at the time of my 1976 revision were erroneous. Thank goodness the herbarium material is there to prove it.

To prepare a data-matrix for cladistic or numerical analysis, it is always necessary to re-investigate character that may have been ignored or misinterpreted by earlier workers. This would be impossible in the taxonomic wasteland proposed by Clifford *et al.*, or perhaps these authors do not believe in such methods.

Finally, because there is at present a shortage of funding in the sciences, it is fair and proper to look at which areas need greatest priority of support. But, under these circumstances, I am suspicious of those who, through ignorance, are prepared to back the destruction of a branch of science other than their own. There is, of course, frustration that the classification and description of the approximately 200,000 species of flowering plant is still far from complete. Today, the need for this is ever more urgent, as pressure on natural environments becomes more acute. The fault, however, is not due to the lack of efficiency nor lack of desire to use modern methods, but is due to lack of resources. Science and industry rely on taxonomists, but there is less willingness to acknowledge that the quality of our expertise is inevitably related to resources put at its disposal.

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SIR—There is a gross mischief about that taxonomic research is unrelated to the curation, maintenance and expansion of herbarium collections. It has even been suggested by Clifford *et al.* that it is not necessary to maintain large collections of plant specimens in herbaria, but instead that most collections can be pulped, replacing them with computerized label data. Such a radical proposal may seem sensible and plausible to many of *Nature's* readers, but it is based on unsound logic and a less than full appreciation of taxonomy as a science. Researchers from other fields should know why we are so upset and should appreciate how the proposals put forward by Clifford *et al.* could eventually affect them.

We have all spent time in European herbaria either because our countries did not have adequately named herbarium material, or because our herbaria lacked types and literature. It was only in these large centres that we could complete our work or find solutions to taxonomic problems raised by our colleagues.

Clifford *et al.* suggest that there is no need to collect representative specimens of plants from different localities, at different times of the year, at different stages of the life cycle, of different ecotypes, with different chemical constitution, and so on, and say that it is wasteful to keep voucher specimens for biological and chemical research. Their suggestions would lead to the destruction of the only validating evidence that the specimen(s) used in experiments was correctly identified. For instance, one of us (C.H.S.) recently collected the few surviving fragments of seeds of sophoroid legumes used by chemists to isolate new chemical compounds only to find that some of the species were not Sophoreae and did not even belong in the family Leguminosae. There were no herbarium vouchers kept. It is probable that many anomalies in the phytochemical and cytological literature are attributable to misidentifications like these.

The preserved specimen is the only object to which data and information, current and future, applies. Preserving only the information on a specimen label would preserve only the presumed identity of the taxon. Clifford *et al.* maintain that living material can be substituted for dried collections. This is nonsense: first, it may not be possible to re-collect the species in the field, and second, comprehensive dried collections from the total distribution range give a far better idea of a species' variability than limited live collections. Further, large, living plant collections would take up expensive greenhouse space and garden facilities. So what money would have been saved?

What stability there is in the classification system is there because the material is available for restudy, fresh material is added from remaining populations, and newer techniques are applied to gather more data. This enhances the scientific value of the material that has been studied as it bears the determinative (identification labels) of generations of revisers and links it to their and other scientists' publications.

The science of plant biogeography, which depends on the accurate identification of plants and a knowledge of where they were collected, would cease to be a viable discipline if herbarium holdings were destroyed. The demise of biogeography would make it difficult to reconstruct past climates given that many plants are sensitive trackers of climatic change. An important tool for the study of global warming would no longer be available. A similar case could be made for lichens, which are valuable in monitoring atmospheric pollution, and algae, which can monitor water pollution.

The literature-based taxonomic system proposed by Clifford *et al.*, which decides for example, nomenclature priority on published descriptions and not type specimens, is unworkable. A specimen allows renewed interpretation and description; a published description is only one person's sometimes prejudiced, interpretation.

The importance of making both type specimens and associated herbarium material available for study is shown by the example of the legume species *Astragalus senferus*. If only the type specimen had been preserved we would probably not know, as we do now, that this species actually belongs to *Cornulaca* in the

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[Continued

Chenopodiaceae. It was the critical study of more complete later collections that enabled the species to be correctly placed. There is also the problem of taxonomic uncertainty, best illustrated by the publication in the 1890s of four different classifications of the tribe Asclepiadeae (Asclepiadaceae). Any reassessment of these differing classifications will have to be based on a study of the same material.

The preservation of well-curated plant specimens in dried or liquid state in herbaria is an essential and basic scientific goal. If there is "massive duplication" that exists for some taxa in some large herbaria then there seems to be a good case to distribute that valuable material more equitably around the globe. Although some large European and US herbaria may be "creaking at the seams", many countries in the Southern Hemisphere do not have a national collection of preserved plants. In such countries, naming is often done by matching against the limited collections in universities and government departments. Despite this, the naming service is probably one of the most important taxonomic services provided to farmers, doctors, hospitals, herbicide companies, gardeners, foresters, environmentalists, conservationists, entomologists, mammalogists, ethnobotanists and ecologists in developing countries.

The real issue at stake is not that herbaria are overcrowded, or that scientific fashion seems to render herbarium taxonomy redundant or that it will be made superfluous by molecular systematics. Rather, it is that although politicians scarcely question the national and regional preservation of cultural artefacts, they fail to understand the real economic significance of the natural 'artwork' of the world, often the resources for manufactured resources. Herbaria are arks of biological diversity, which should be, be esteemed for their immense aesthetic, intellectual and scientific contribution to the broader communities they serve, rather than be pulled down and their contents and expertise thrown to the winds.

C. H. Stirton

(South African Liaison Botanist 1978–80)

L. Boulos

(Kuwait University)

T. D. MacFarlane

(Australian Botanical Liaison Officer 1989–90)

N. P. Singh

(Indian Botanical Liaison Officer 1990–91)

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SIR—The Commentary by Clifford *et al.* is irresponsible and thoughtless. The authors say that accurate identification of taxa is of prime importance to most biological research, but they devalue the importance of herbarium specimens (except type specimens) as the basis for all botanical classification. Herbaria contain evidence of where a plant occurred and how its appearance varied over time and space, providing physical and biological parameters of the history, biology and relationships of the taxon. It is impossible to obtain these data other than by examining herbarium specimens. As the plants of the world disappear, herbaria will become a primary means of studying and understanding the principles that govern the fate of those that are left.

Type specimens of species names are essential to fix their position in the nomenclatural system. But they are not necessarily typical of the morphological variation of a species. To be an effective tool for research, a herbarium must contain a geographical and morphological range of each species.

As new methodologies revolutionize taxonomy, herbarium material is re-examined to produce up-to-date classifications. The suggestions by Clifford *et al.* that plants can be re-collected ignores the fact that in many cases the original plant populations no longer exist or have been significantly changed. Moreover, the preserved specimens obviate the need to re-collect rarities, and re-collection is often costly or impracticable. With modern technologies, herbarium seeds have been used to resurrect species extinct in the wild. Many published descriptions are inadequate: a specimen is worth a thousand words. A recent study of the Australian Orchidaceae, for example, revealed orchids were misapplied by people who had relied on descriptions rather than referring to the original specimens.

We regard our herbaria as the most valuable asset in our broad-based research programmes. In studies of diversity, cytology, plant chemistry, agriculture, forestry and medicine, herbaria are the most cost-effective method of encompassing variation. Improvements in our knowledge depend to a large extent on the quality and selection of materials collected since the previous revision; this applies particularly to unexplored regions. Herbaria, therefore, must grow. The cost of maintaining specimens as part of a broader research programme is relatively small.

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[Continued

N. Chalmers
Natural History Museum, London

D. Hawksworth
International Mycological Institute, Kew

D. S. Ingram
Royal Botanic Garden, Edinburgh

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G. T. Prance*
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Further correspondence on this topic will be considered only if it makes any new points.

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Examination of witnesses

PROFESSOR G T PRANCE, Director and PROFESSOR G L LUCAS, Deputy Director and Keeper of the Herbarium, Royal Botanic Gardens, Kew, called in and examined.

Chairman

322. Good morning. Before we get to the questions may I say how grateful we are to you both for coming to see us this morning. We have your evidence and we have various questions for you. I wonder whether before we start you would like to make any general statement or say anything to us before the questions?

(Professor Prance) My Lord, I think the most important thing is that I am delighted that this subject is being given a hearing like this and I have stated most of the things in my written statement. Systematics is such a vital process for any biologist and I think that you are helping to draw attention to it. I am very pleased and I think I would rather answer the specific questions that you would like to ask me.

323. I have no difficulty in agreeing that systematics is vitally important. I would like to start the questioning by saying why do you think that it is in the state that everyone thinks it is in? Why is it that systematic work does seem to have dropped out of university teaching? Why is it that systematists give the impression of feeling that they are second-class citizens?

(Professor Prance) I think there are two main reasons I would like to point out. The first one is that science tends to follow the new and the fashionable things and so there has been a definite tendency to think of things like molecular work as more glamorous so the funding, too, has followed that pattern at the sacrifice of systematics. Secondly, I think that systematists, or a very large number of them, are very enthusiastic about their work and all they like to do is sit there and study their group of plants in their laboratory or group of insects or the work they are working on. So they have not been the

best sales people for their science. It is only as it has declined that a large number of systematists have become more vociferous in defence of their science.

324. What do you regard as the best remedy for this unhappy situation? I see exactly what you are saying but given that funding is inclined to go to the glamorous subjects, how do you see systematics making itself more glamorous?

(Professor Prance) The most important thing is that it does need more funding and not eroding from other areas the money that goes to systematics. Systematics can only serve as it should if it is adequately funded. I think because of the current environmental interest there is a definite interest in systematics. It is not a difficult subject to sell. There are lots of students at universities who are interested in it.

325. But there is little teaching, we understand, in universities?

(Professor Prance) That is right.

326. Why?

(Professor Prance) I was talking to someone in the University of Wales the other day who was telling me that for their elementary courses in systematics they can get 100 students coming into the course but there is not the teaching because part of the erosion has been that universities have committed their priorities elsewhere into more experimental sciences and when systematists have retired they have then been replaced by a molecular biologist or one of the other areas rather than systematics. I think this trend has been general in whole plant biology—not just systematics and people who study the whole plant have been replaced by those who study the cell, chromosome and the molecule.

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PROFESSOR G T PRANCE AND PROFESSOR G L LUCAS

[Continued]

[Chairman contd.]

327. I think my problem is that I can see exactly what you are saying and I have a doubt in my mind that systematics is unglamorous and therefore it is unexciting and gets less funding. How would you propose to make it command more funding?

(Professor Prance) Well, I think first of all that the environmental crisis that we have now—and all of the people who come to us at Kew who are asking for information and we are worried that we are not able to provide it—is to highlight the demand there is for systematics. With the current interest in the environment—looking for sustainability of ecosystems, providing information to stop the deserts encroaching on areas—we are bombarded with questions and we feel unable to answer them. I think to make systematics glamorous we can point out many of its uses. Looking for new medicines is another area with which we have been involved at Kew. I think this upward trend has come about in this country, certainly in the last 5 years, and what you are doing today is part of that.

328. I have a great deal of sympathy for that but can I change now to noting that you proposed a new Biodiversity Research Council. I wonder whether you would like to expand on that suggestion as to how you would like to see that develop?

(Professor Prance) Yes certainly. I would first of all like to point out that at Kew we are very happy with our relationship with the Ministry of Agriculture, with MAFF, and that is the prime source of the grant-in-aid funding of our systematics. In proposing this I am in no way criticising what is going on at Kew from the Ministry of Agriculture. We have a very good working relationship with them and that is providing a great deal towards the funding of the systematics that we do. I feel that a Biodiversity Research Council of some sort could play an important coordinating role on a national basis and it would involve some of the biodiversity institutes in determining some of the direction of the research. Currently Kew is not really well-represented on committees which determine the research policy or additional competitive funding. I think that if there was a council that had available to it grants that gave competitive funding it would provide that element of competition for extra funds to do some of the projects that we are not able to do now that we want to do. The right projects would come out through coordination. I would also see as a central role of a biodiversity institute perhaps having some grants that encouraged interaction—consortium grants, grants for a university to work with a biodiversity institute. There are similar things within the National Science Foundation in the United States with which I am very familiar and obtained some grants when I worked at the New York Botanical Garden. Collaboration between a university and non-university institution is the only way you can compete for the certain pool of funds. That sort of thing stimulates new research and also helps cohesion between the different types of institutes that are involved in systematics.

329. Do you see any problems about overlap with other research councils and, if so, how would you deal with that?

(Professor Prance) There is obviously some overlap with other research councils but in general if you look at what the other research councils are doing now, they are not the ones that are primarily funding any systematics at the moment. So I do not think that there is very much overlap. Everything you did you would obviously review first as a prerequisite to see what the existing situation is and perhaps modify something in there before you set up a new one.

330. Obviously from what you have just said you are advocating links between institutions and universities. Would this be your primary mechanism for suggesting how this should come about, or have you other ideas?

(Professor Prance) That was my suggestion of one of the functions of such an institution, not necessarily the only one. Competitive grants for systematics with the funds that are available is the prime role I would see in it, and the consortium collaboration being a part of that competition.

331. I take it that would be primarily for research collaboration. Do you see an importance in teaching collaboration between universities and institutions?

(Professor Prance) Yes, I do. Teaching is something that we are already doing a lot of at Kew and other institutions. There are a large number of postgraduate students whose theses are supervised jointly between a staff member at Kew and another university, in particular Reading, some of the London colleges and Oxford University. I think that the teaching relationship with a biodiversity institute is a very important thing. If your main task is to do research, something that helps a great deal is the stimulus that you get from interaction with the students. So it keeps the biodiversity institutes on the cutting edge when they are interacting with students. Already this is under way, but it is something that could be enhanced and it would be better if there were more university supervisors who were trained in systematics—they are depending much more upon us—and especially now that the universities are encouraging overseas students to come. They come often to us with a job in systematics back in their country and there is no one in that university to supervise them so where do they come? They come straight to Kew and it is an increased burden, if you like—it is a welcome one but it is something we are gradually developing.

332. I would like to press you a little bit further on that because I think you were primarily concerned with the teaching of graduate rather than undergraduate students. Do you see a complementary role for the institutions to play in the teaching of undergraduate students in universities where we agree the teaching is very slim?

(Professor Prance) A certain role, but I think the level of our research gives us a much more logical relationship with postgraduates. However, many university classes used to visit Kew—a few do still—at undergraduate level and we have had staff members who have taught in university courses, but I think our primary role is, because we are a research institute and have that experience, to interact at the postgraduate level rather than the undergraduate

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[Continued]

[Chairman contd.]

level. We would like to see the universities enhancing the undergraduate level and providing the students that come to us. My concern is that the graduates who come out of university, and whom we are looking to hire, do not have the background, and I would like the universities to provide that for us rather than our being involved in that. Division of labour is important.

Lord Flowers

333. My Lord Chairman, this is getting far too technical for me. You are asking for a new Biodiversity Research Council all of your own, so to speak. Biodiversity is a very important aspect of biology, but there are many other important aspects of biology and many important aspects of chemistry, physics, so on and so forth. Is each recognisable important aspect of every subject going to have its own research council? Most of us are thinking in terms of combining research council activities rather than splitting them up in this way. I think you have to make a very strong case, if I may say so.

(*Professor Prance*) Yes. Thank you, I agree. Biodiversity is the basic, and we did deliberately say biodiversity and not systematics research council, which is much more all-embracing. Obviously one wants to have a cohesion rather than a splitting up of these things, and collaboration. What is the best mechanism? All I know is that what we have at the moment is not really catering to the needs and demands of biodiversity in a time of increasing environmental concern and needing to react to the environmental problems of today.

334. Would it not be enough though if, let us say, NERC—anyway, one of the research councils—were to set up some special subdivision which concerned itself with biodiversity in the widest sense, co-ordinating the work of other research councils in that area if necessary?

(*Professor Prance*) Yes, it certainly would be enough if it was part of NERC. We would be quite happy. We have not given great thought to the exact mechanism, that is not really our role. We made the suggestion that in some way something that gives more attention to biodiversity and systematics is needed within the competitive research funding and also that the sort of institutions which I represent are given a bit more say in the policy setting in this area.

Lord Flowers] Then I am nearer to you than I had thought. Thank you.

Lord Porter of Luddenham

335. Could I follow that, Lord Chairman? As Lord Flowers has said, it obviously would not be on (we have five research councils) to have six with one of them being the Biodiversity Research Council. It would not fit in there. But there has been—and I would like to ask your opinion on this—quite a lot of talk about having a separate Biology Research Council, a research council for the biological sciences separated from the physical sciences. What is your opinion of that? Would it be any help to your own subject?

(*Professor Prance*) Yes, my Lord, I think it would be of help to have one devoted to biology and it

would probably be uniting to biology. The biological approach is quite different from the physical sciences and I think that might be very good. I would argue, if there was that, the most important thing would be that it did not forget systematics and that there was a strong representation of systematics on it.

Chairman

336. You have suggested, I think, that the various sub-disciplines within systematics should be determined by national needs. I wondered what sort of mechanisms you had in mind for that determination?

(*Professor Prance*) I think the most important thing is that already some of the needs in that are determined by regular meetings that we have with the government committees that come to us on this. I just think that it is not really co-ordinated enough at this stage. We have not really worked on the mechanism for it at this stage.

337. Are you subject to a priority board mechanism that the MAFF has for determining its priorities in research, since you are funded by MAFF?

(*Professor Prance*) No, we are not. We have just recently had a visiting group to review our scientific programme and that is something that MAFF like us to do on a regular basis, but we are not subject to any board like that.

338. What sort of proportion of your budget goes on systematics research? Your budget is roughly what, and what is the systematics research side of it?

(*Professor Prance*) Our budget last year, excluding capital building, was £12 million from our grant-in-aid from the Ministry and approximately 39 percent of that went directly to systematics. That is supporting the Herbarium and Library, our Jodrell Laboratory, and taking a third of our living collections being counted as part of the systematics. So that means we devoted £4.7 million to systematics directly. Now, that does not count the other supporting functions that obviously a lot of our money goes into, providing the lighting, heating, buildings for systematics to take place. So another proportion of our budget comes in on overheads. It is the direct grant-in-aid amount which is £4.7 million. In addition to that we have other small sources of funding including a small endowment which gives us about £50,000 to contribute directly to systematics, projects that we get from ODA, projects from private concerns, which add directly into our systematics research something of the order of another £150,000 a year.

Lord Whaddon

339. I notice that there is this move towards the assembly of a world check list for species. This could be pretty prestigious and attract a lot of attention to your whole subject if it were to be set up in Kew but you do say you are not sure that you can afford it. How much extra would this be?

(*Professor Prance*) To do it properly, to set up the programme that we want to, it would be approximately half a million pounds a year extra to do that in the way that it really should be done. It

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PROFESSOR G T PRANCE AND PROFESSOR G L LUCAS

[Continued

[Lord Whaddon contd.]

needs a lot of new computational ability and quite a lot of it would go on that and we want to provide the coordinating hub for this where many many other institutes will work with us. We had a meeting of the eight major botanical institutes in the world and when Kew offered to be the secretariat they were very pleased with that. It is something that will add prestige to Kew and to our nation if we were to do this. We are doing what we can with our limited staff. We really need half a million more pounds a year for the next 5 years in order to make it work.

Chairman

340. With your expenditure on systematic research at roughly £5 million in order of magnitude, do you have an order of magnitude sum that you would be happy with? Is that 10 per cent of what you would like to have or is it 75 per cent of what you would like?

(Professor Prance) I think it is nearer to 75 per cent of what we would like to have. We have, I suppose, at present in our systematics section about 10 per cent of the posts vacant because we cannot afford to fill them; posts that are authorised in our staff structure. As scientists have retired we have not replaced them so we have a very definite lack of that 10 per cent of people. Then there are various other things that support that, particularly I feel we are lacking in the support staff. Many of the scientists are filing the specimens and doing things where greater support is due because we are putting our support into the scientists. So we are approximately 25 per cent short, we feel, to do the things we should do.

Lord Flowers

341. I have one question I wanted to put. I am not sure we have explored it sufficiently. Somewhere in your evidence you talk about short-term pressures being brought to bear on research of systematics. What is so sad about that? In every subject I have every had any dealings with there are short-term pressures to do things of national need or to do things that an industrial firm thinks would be important or whatever and this is a fact of life and it shows that science is useful.

(Professor Prance) Thank you for that observation because it gives me an opportunity to say something very important about systematics where it does differ. Obviously we respond to a lot of short-term needs as well. Suddenly there is some importation of orchids and we have to get involved in orchid taxonomy or something we had never thought of doing or a response to a project for the ODA somewhere. But systematics is a long-term science to provide the basic database about plants. One needs to analyse the plant family, study all the specimens, study all the literature and then produce a monograph that essentially produces the book from which future people can identify that particular group of plants. You can only do that over the long-term and in that way systematics is quite different from many other sciences. You may set out with a 20 year goal to completely revise a particular plant family and that is how systematics should work. My concern is more that we cannot offer that long-term stability to do that unless there is stable funding, we

should not have to do all the responding in the short-term and anyway we cannot respond to the short-term things unless we have done that long-term research.

Chairman

342. I am puzzled. Again I go back to the training issue about the disparity between employment and enthusiasm for the subject. At one place in your evidence you say there are a lack of employment opportunities but you also on the next page say that you have had very considerable difficulties in drawing students into this field. Also, I think you said earlier that there was considerable enthusiasm amongst people, particularly in the University of Wales. Are there lots of systematists being trained for very few jobs? What is the match at the moment or mismatch?

(Professor Prance) I think the mismatch is definitely that there are not enough students being trained in the United Kingdom. Dr Barry Thomas of the National Museum of Wales did a survey of 20 university botany departments and the number of whole plantbotanists employed fifteen years ago, ten years ago and this year were reviewed. There were 82 fifteen years ago, 82 ten years ago and 68 five years ago and only 43 in 1991. The estimated number of taxonomists in that was 39 fifteen years ago, 37 ten years ago, 27 five years ago and 22 at present, which includes three bio-chemists and two palaeobotanists which are peripheral to the total of 22. There is a definite decline. I think those figures indicate in real terms what is happening in universities. The result is that undergraduates who have got interested in environmental issues and might go into the taxonomic area are going into other areas because there are not the enthusiastic teachers to take up that part of it which would stimulate them into being systematists. We advertise quite often posts for systematists at Kew and that is a good measure when the candidates come forward. What impresses me is that we are getting a large number now from certain EEC countries and they are definitely better trained than the majority of United Kingdom students. Of course, there are some exceptions. There are some very fine ones coming out of our university system too but if you take the pool you see that Denmark, Germany and Spain in particular are obviously training a lot more than we are. The basic plant taxonomy courses in Spain in some of the Spanish universities is ahead today.

343. Is Spain providing the job opportunities for them?

(Professor Prance) To some extent it is, in that they have founded several new botanic gardens over the last decade in Spain and those are employing quite a few. University botany departments have tended to be increasing in Spain, I think, better than anywhere else. Some of the other countries that are training systematists, notably Denmark and the Netherlands, are not providing the jobs to go with them, which is why maybe we get a great many applications from particularly Denmark and the Netherlands.

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PROFESSOR G T PRANCE AND PROFESSOR G L LUCAS

[Continued

Lord Taylor of Blackburn

344. Are you getting any applications from other countries, apart from the European countries?

(*Professor Prance*) Yes, we are. We would employ someone from elsewhere only if it was a special case. Obviously then we make a case with immigration to get them, but it is only if there is a very specific reason to have them as opposed to someone from the United Kingdom or the EEC, but we do get applications. We have just recently, for example, needed someone to study ferns and by far the best candidate was somebody who is a New Zealander and we employed him as our fern specialist. He was way ahead of anyone else whom we had, so we obviously made a case to get this very fine New Zealander on our staff.

Lord Porter of Luddenham

345. Professor Prance, I am still a little puzzled as to what the problem is when you go down from 39 to 22 systematists. Let us talk about this country rather than people coming from overseas and so on. You have said at one point that the young research workers are tending to go into molecular biology and the jazzy new subjects like that. You did say earlier you had 100 applications for a position or positions of this kind. I do not understand. Is the problem that there is not the demand now because the young people are going into other more modern fashionable branches of science or is it that there are not enough positions for them?

(*Professor Prance*) Part of the problem is that there are not enough positions—the down side—and because there are not enough positions students are put off from going into systematics. There is certainly an awareness that, if you are going into systematics, the job prospects are not as good as they are in other fields. So that is part of it. When I mentioned that at Kew we are holding various positions vacant at the moment, well, that means that we are actually recruiting fewer people than we might have done and so contributing to the lack of demand of jobs. Nevertheless, we see the other side of supply as much smaller in the United Kingdom and much less trained than it used to be. What worries me is that a lot of the supply we get now is people whom we ourselves have trained in conjunction with Reading University. That has a good programme and I am delighted with it, but I would not want to fill all our staff positions with people from one school. It is something that is very important, to bring new ideas from different places trained by different professors, to have the choice. We need on our staff to have this variety of backgrounds coming in rather than all coming in through one uniform one because that is the botany programme that is surviving well.

346. What would you say to a young biologist or young scientist whom you wanted to persuade to go into systematic biology? What would you say is the attraction of it? I suppose, unlike most other areas of science, there are no glittering prizes, are there really? Can one have a break doing this subject which is something that makes one famous?

(*Professor Prance*) It is unlikely, there is not something like a Nobel prize. But, on the other hand, I think the rewards are in what you discover. I would talk to a young person about the excitement of the plant systematics, finding out about how plants

work. The evolutionary relationship of plants is absolutely fascinating. My own work is going to the Amazon forest and seeing how the whole thing holds together with the pollinators, the dispersers, the insects that protect some of the plants, and understanding the whole ecosystem—it is an absolutely wonderful challenge to anyone. There are a lot of young people interested in the environment who will respond to that. I would say to them still today, if you really want to do it and you are enthusiastic about it, do it; and the good ones will come through and be employed by the institutions like Kew and the Natural History Museum where there are still a few opportunities. It will be the good ones who are really stimulated by their natural curiosity into biology. That has been very rewarding for me and for many of my staff who have really been enthusiastic about what they are discovering themselves about new relationships.

Lord Porter of Luddenham] Thank you very much. I think I would have gone for that if I had been a young student thinking about it.

Lord Taylor of Blackburn

347. May I follow this one up? What relationship have you with the NRI, the Natural Research Institute?

(*Professor Prance*) As far as I know, we do not have any relationship with them.

Baroness Nicol

348. What you were just saying seems to lead us naturally almost to the last questions on our list, and the philosophical one of why seek out new species? If they are not known to man, why should we miss them if they become extinct? It seems to me your suggestion just now was that the job brought satisfaction in itself. It would be helpful to hear how you see the practical applications?

(*Professor Prance*) Yes, certainly. Thank you for that question too, it is a very important one. New species may not be known to the scientists and scientists may not have given them a name, but those species are playing quite often a vital role in some ecosystem, holding it together; if you remove them the system might crash. Many of them are known by local people who know them by a vernacular name and are using them in some way. For example, I was in a place in the Amazon and studying a local plant that was very important. It sustained several soap factories in the region; everybody extracted the oil from it for their cooking. I collected specimens of this because I had not seen it before and it looked rather strange. I took it back and analysed it in my laboratory and found it was an undescribed species. They had known it for years as *castanea de cutia* or the agouti nut in Brazil but there was not a specimen in the Kew Herbarium or the New York Botanical Garden Herbarium until we collected it. You would not say just because it did not have a name it did not matter. It has since been industrialised a bit more widely in Brazil. If you wanted to go back and collect it, if you wanted to go out and collect a population to study its variation, to bank the seeds, to plant it, you would really need that basic handle of a name on that plant. Countless undescribed species may contain medicines or perform some other utilitarian role, and

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[Continued]

[Baroness Nicol contd.]

if we collected one, tested it at Kew and found it had a medicine in it, we would want to have a handle so that we could refer to it and always go back and get that same thing again. I think it is vital that we do continue and get all the species in the world catalogued.

Lord Whaddon

349. Are there any known instances where mankind has lost out where a species has disappeared?

(*Professor Prance*) There are certainly many places in the world where species have disappeared and we could list that in great detail. We know what some of the extinct species of plants are. There are certainly various plants or various animals that are unable to function because another species has gone extinct. I think one of the best known ones is the tree in Mauritius of which there are only very few left because they germinated by going through the gizzard of the dodo and when the dodo went extinct that plant had no capacity for reproduction.

Lord Flowers

350. Does it matter? Darwin had something to say about this.

(*Professor Prance*) Extinction is a natural process and any biologist would agree with that. What has happened today is that extinction rates have exceeded any previous ones and that is causing ecosystems to crash. The other thing about natural extinction is that in many many cases the genetic material has lived on because it is evolution rather than extinction. The birds of today represent some of the genetic material of the dinosaurs, for example. We say they have become extinct but there is some of that material going on in the process of evolution. A lot of the process is changing rather than becoming extinct even though the rain forests of coastal Ecuador have been cut down.

351. It seems to me to be a somewhat philosophical questions as to whether the manmade destruction of species of the kind you are talking about now is really any different from the destruction of species which has taken place millions of years ago by natural events. The earth warms up and that has an effect on species presumably, or it cools down ditto. These did not happen to be caused by man as far as we know. They were natural events and nobody says that is a terrible thing. You just have to accept it. Why should we not just accept what is going on now? It is also a natural phenomenon because man is part of the natural system.

(*Professor Prance*) The main reason is that if man himself wants to survive he will need the genetic diversity with which to survive and what we are doing is eliminating some of the things that we need for the future, some of the basic things that we use in our daily lives. We depend not only on the crops that we plant but some of the wild species in the forest. A few years ago a new species of maize was found in Mexico remaining on one small hillside where agriculture was taking place and it was very tenuous. It could easily have become extinct very soon after it was discovered by a taxonomic botanist in 1976. That

species is perennial and it adds to the potential of the capacity of the crop of maize to become perennial. It was also resistant to 6 of the major diseases of maize. Now the genes that are in there are absolutely essential to the maize crop. What a pity for feeding the world if we had lost that. We drink a lot of coffee and we have the world expert on coffee working on our staff at Kew. Now there are lots of diseases of coffee so the 30 species that Diane Bridson is studying in Madagascar may contain the genetic material on which the future of coffee hangs. There are also such interesting things as some of the wild species that do not contain any caffeine in them. Instead of going through the chemical process maybe we can produce natural caffeine-free coffee. I could go on with hundreds of examples showing how much we depend on genetic diversity. We are taking destruction too far in general, too much extinction is going on and it affects our capacity to survive.

Chairman

352. How much is Kew itself entering into the kind of work you describe, as a consequence of finding this perennial maize species? Are you involved in the molecular genetics that will follow on this discovery or is that something that is to be left for others?

(*Professor Prance*) We are not involved directly in the manipulation of plants like that. We cooperate with other people and very often when someone is doing genetic manipulation like that they will come to us for advice on the wild species of a certain crop or ask us to collect certain things. We are not doing that because there are many other institutes doing that and it is part of the natural division of labour within the biology community.

353. Are you thinking of setting up a molecular systematics approach to plant taxonomy?

(*Professor Prance*) Yes, very definitely. We are thinking of setting up molecular systematics and the key to it is that word "systematics". We want to use molecular techniques as an extra tool in understanding the evolution and the classification of plants. Over the years systematics, which is a science of synthesis, has added new techniques. Microscopes have improved and you can get the electron microscope so you can look at a new level. We have to start assimilating the data of what pollen looks like 50,000 times magnified. Today we are able to look further inside the plant into its molecular structure and what the DNA looks like. So it is yet another advance and it is a more stable one than some of the other ones. However, it does not give the information that the practical person needs. If the farmer or forester wants to identify a plant he cannot grind it up and look at the DNA. We provide the morphology as the basis of that classification but it will be much better if it has got some molecular taxonomy built into it.

354. I have always had difficulty with this. DNA is about the individual and systematics is about groups. I have often wondered whether there is a difficulty there?

(*Professor Prance*) No, there is not really. The DNA can be used at the individual level. We could use it for legislation. One of the applications we

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[Continued]

[Chairman contd.]

expect to use on our molecular biology is: if we have got an orchid coming in and they claim it is from cultivation of a certain stock, we would be able to look at that and say whether that is right or whether it came from a wild species. That is the individual level but then seeing it is such a stable character of the plant the changes in the DNA over thousands of years will help you to get a much more rational evolutionary relationship between the plants at that level. You would be working with a much broader part of the taxonomic system, with the genus, with the families and how they work together. Another interesting thing about the DNA side is that the phenotype which is what you see when you look at plants is controlled by about 10 per cent of the DNA. You are looking at lots of non-apparent characteristics in the genome.

355. I think that is the line I am interested in because if you were going to look at the other 90 per cent that does not control the phenotype then you are looking at something which is in a sense irrelevant to the classification which is mostly done by phenotype, is it not?

(Professor Prance) It is not irrelevant to it because it is giving information that will relate this biologically and give you a new insight and your phenotype classification will be better because it is a truly evolutionary classification and it is relating closely related things and that is very important to know.

Chairman] I am sorry; I should probably not pursue that. Are there any other questions?

Lord Whaddon

356. I wanted to ask something out of pure personal curiosity that has always puzzled me. We are talking about the loss of species as if they have gone forever. We assume they have gone forever but genes themselves have evolved. They were not always there; they themselves have evolved. Why do they not evolve again?

(Professor Prance) The answer is probably very very complicated and some of them may in those continuations. But many genes have properties will be lost. We cannot survive with just one type of gene. Science will never be able to produce everything from the genetic material of one species.

357. As far as we know when they do go they are gone forever?

(Professor Prance) As far as we know, yes.

Lord Porter of Luddenham

358. By the natural process, but with the new very rapid developments in genetic engineering by man can we not force them to come back?

(Professor Prance) No, we must take the gene. We can take a gene from one organism and put it in another, but we need the gene. If it has gone, become extinct, we cannot then engineer with it. That is the danger. Maybe that resistance to corn blight was only in *zea diploperennis*; if it had gone extinct, if you had not had that gene, you could do all sorts of miracles but you would not have that particular gene, whose effect over the years has been in regard to corn blight, to build up a natural resistance. You have to

have evolutionary periods for the various traits to evolve which then become genetically controlled. The presence of the disease leads to the evolution of a gene that gives that resistance to corn blight.

359. You do not feel man is yet in charge of evolution?

(Professor Prance) No, I do not.

Chairman

360. Could we go back to the question as to division of labour and, in particular, the agreement between you and the Natural History Museum which I think is known as "Morton's agreement", a division of activities, as it were? How does that work and how does it include, or does it include, other institutions?

(Professor Prance) The Morton agreement is an agreement just between the Royal Botanic Gardens, Kew, and the Natural History Museum which was set up obviously to divide responsibility for the study of the world's flora in geographical terms and in systematic terms. They have the mosses and the lichens, we do not have any, as part of that agreement, for example. An agreement obviously made sense, having two major systematic institutions in the country. The collaboration as a result of the agreement is obviously much wider. The keepers of Kew, the Natural History Museum and the Royal Botanic Garden, Edinburgh, meet annually and discuss the joint research programmes and in those meetings the Morton agreement is discussed and obviously that brings Edinburgh into the process as well. I sit on the Science Advisory Committee of the Royal Botanic Garden, Edinburgh, so I see what is going on there. There are a lot of similar interactions with other departments that I think see that there is no duplication. I think within this country we have got that well worked out. Professor Lucas here represents me on the annual meetings with our sister institutions.

361. So were the changes that have taken place, or are going to take place, in the Natural History Museum discussed at those meetings? Were you consulted about the changes of concentration of procuratorial activity?

(Professor Prance) There was no specific discussion between Kew and the Natural History Museum prior to their restructuring. However, we know they were aware of Kew's research thrusts as agreed by the meetings of the keepers and we certainly see that the changes we know about, which they have made and which we have discussed with them since the changes, do not impinge on anything Kew is doing or our major spheres of interest. So I think that, even if there was no discussion, certainly the result of it continues in the spirit of the Morton agreement. We are worried, however, about some of the groups of plants that have become neglected over that. We feel that the Morton agreement process is irreversible and so we are a bit worried about algae and mosses in particular that we have relinquished—and we certainly do not intend to take them back.

362. Why do you think the Morton agreement is irreversible?

(Professor Prance) I did not say the Morton agreement. Obviously we have our on-going

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[Continued

[Chairman contd.]

discussions with the Natural History Museum and we might make some changes. What I think is irreversible is actually the transfer. Transferring of large groups of plants back and forward from one institution to another would not make sense in terms of expenditure, time and everything else; I would like to think it is irreversible.

363. The physical location of the specimens is irreversible?

(Professor Prance) Yes.

364. You suggested a European strategy for a network of institutes? Is this being established? Is there any initiative taking place along these lines, and how far could co-ordination be taken in European institutions?

(Professor Prance) We work very closely with European institutions and our discussions on what we do and who we collaborate with certainly take us into Europe. What I was saying there is that we need to co-ordinate it more as well on the funding basis. As far as I know, at the moment there is no money going from the EEC into the science of systematics. From our experience with the EEC there is a lot of work to get any programme, a lot of lobbying, a lot of time spent on it to get some results, and I am suggesting to have some EEC funding for systematics should be part of the picture, not just that all the responsibility should be put on the United Kingdom. So we would be very happy to work with some of our sister institutions, should we feel that there was hope of achieving something there.

Lord Flowers

365. My Lord Chairman, if they and their British colleagues were to get together and approach the European Science Foundation, which exists to bring research councils across Europe together to do joint things (I know you are not funded by a research council, that is why I say with your British colleagues), you could between you in a number of countries put up a programme for a network system which could be submitted by the ESF to the Commission to fund it. That is the route for doing this sort of thing nowadays, if I may offer that piece of advice.

(Professor Prance) Thank you.

Chairman

366. There is nothing specifically in the Brussels programmes which precludes EC European expenditure on systematics, is there?

(Professor Prance) No, there is not, but on the other hand there is nothing that is really contributing greatly to systematics funding at the moment.

367. Is there anything further you would like to say to us?

(Professor Prance) I do not think so. You have asked me most of the things I wanted to say, my Lord, and thank you.

Chairman] Thank you very much indeed for your evidence.



MINUTES OF EVIDENCE
TAKEN BEFORE

THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 21 May 1991

THE ROYAL SOCIETY

*Professor B K Follett, Professor J L Harper, Professor J Maynard Smith
and Mr A J Leaney*

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TUESDAY 21 MAY 1991

Present:

Butterworth, L.
Dainton, L.(Chairman)
Flowers, L.
Porter of Luddenham, L.

Selborne, L.
Walton of Detchant, L.

Memorandum by The Royal Society

1. INTRODUCTION

The Royal Society is pleased to submit evidence to the Inquiry into Systematic Biology Research. The following evidence, which has been endorsed by the Society's Council, was prepared by ad hoc group under Professor J. L. Harper. Other members of the group were Professor R. J. H. Beverton, Professor A. D. Bradshaw, Professor B. C. Clarke, Professor C. J. Leaver, Professor G. A. Parker and Professor J. Maynard Smith.

2. SYSTEMATIC BIOLOGY

Systematic Biology builds on taxonomy (the systematic giving of names to specimens) to investigate relationships between organisms. It provides essential infrastructure for virtually all biology, including palaeobiology.

The development of a corpus of observational and experimental knowledge in biology is impossible without an agreed method of identifying organisms. Taxonomy and systematic biology thus vital to research in such field as evolution, ecology, biodiversity, behaviour, physiology, and genetics and genetic engineering. These fields are of direct practical importance in agriculture, medicine and biotechnology: for example, the continued development of effective pesticides demands an understanding of the interactions between pests and plants and of the evolutionary adaptations of pests to changing environments. Systematic biology is thus both a basic and a strategic science of pervasive importance.

The development of molecular biology has provided a range of powerful new techniques for systematics research. For example, the availability of exactly characterized gene probes and DNA sequences allows detailed analyses, at the molecular level, of the degree of relatedness of different species. This opens up new possibilities of subtlety and precision.

3. THE GLOBAL POSITION OF THE U.K.

The political and scientific history of the U.K. over the last three centuries have given the UK unique opportunities, but also unique responsibilities and a unique burden, in the amassing and curating of natural history collections. The international importance of the collections held in the UK may be illustrated by the fact that, when the scientific work at the Natural History Museum appeared to be under threat last year, the President of the Royal Society received 530 letters of protest from more than 30 countries all over the world.

Other areas of biological research tend to attract greater attention from British researchers. The opportunities for systematic biology now available in the UK, largely as a result of earlier imperial history, are however legion. Indeed, they would seriously distort the overall balance of biological research in the UK if they were fully exploited by British researchers.

There is a strong argument that, to the extent that collections at present in the UK are a major international scientific asset, some efforts should be made to share with the international scientific community a degree of responsibility for the maintenance, and the financing, of the collections. One possibility would be to disperse some holdings, for example by relocating specific collections via long-term loan to relevant user groups in other countries. Other possibilities include charging for access to collections, facilities and expertise; and securing recognition (and funding) as an international centre of excellence, for example via appropriate mechanisms at both regional level (eg the European Community) and international level (eg United Nations.)

4. FUNCTIONS AND FUNDING OF MAJOR INSTITUTIONS IN THE FIELD

(a) Functions

Institutions like the Natural History Museum (NHM), the Royal Botanic Gardens, Kew, the Royal Botanic Garden, Edinburgh and university herbaria have a number of distinct functions:

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- (i) the traditional curatorial function, i.e. acquiring, maintaining, and augmenting collections of samples and the library resources associated with their study (including floras, faunas and monographs);
- (ii) taxonomy, including provision of information retrieval capability;
- (iii) providing the scientific underpinning of disciplines such as chemotaxonomy, phylogeny and molecular systematics;
- (iv) supporting researchers, for example in biodiversity or ecology, who need access to (i), (ii) and (iii);
- (v) supporting user groups in industry, for example those concerned with biotechnology or pest and disease control;
- (vi) public awareness.

(b) *Funding*

Funding for the centres of taxonomy and systematic biology in the UK is provided by a variety of sources, in a somewhat curious pattern. Thus, the NHM is funded through the Office of Arts and Libraries; Kew is funded through the Ministry of Agriculture, Fisheries and Food; the Royal Botanic Garden, Edinburgh is funded through the Department of Agriculture and Fisheries for Scotland; the Commonwealth Mycology Institute is funded by the Overseas Development Administration, and systematics research in universities is funded by the Universities Funding Council, the Research Councils, and various customer Departments.

This diverse arrangement, due mainly to historical accidents, does not appear to work too badly. However, there would be advantages in tying funding more closely to the several functions of the institutions so that their research work could be peer reviewed against the research work of other groups. Thus:

- functions (i) and (ii) should be funded from core grant-in-aid as at present;
- functions (iii) and (iv) should be funded by competitive research grants and contracts from the Research Councils and from customer Government Departments. Associated studentships should be funded similarly;
- function (v) should be funded by industry;
- function (iv) has two aspects. The educational aspect should receive grant-in-aid, like functions (i) and (ii); the entertainment aspect, so far as possible, should be self-financing.

The implication of these suggestions is that, within the Research Council system, there should be an identified source to which funding applications for systematic research could be directed. In the absence of a single Biological Research Council, the Advisory Board for the Research Councils should consider how a Systematic Biology Committee, with associated funds, could be established within the existing Research Council framework. This Committee should be empowered to receive applications both from Institutions of Higher Education (HEIs) and from museums and analogous institutions.

5. FOCUSING RESEARCH INTO SPECIFIC AREAS

There is a risk that the dramatic development of molecular biology on the one hand, and the pressure to maintain and enhance a powerful base in taxonomy and curation of museum collections on the other, could reduce to far the resources available for work on living collections, on the biology of living organisms and on biodiversity. We therefore emphasise the importance of animal collections, botanic gardens and living culture collections.

That said, systematics research should not be artificially focused into specific areas. The distribution of effort should be allowed to emerge from the process of competitive bidding for research grants described above. This will ensure that the highest quality research is done; and in the long run 'usefulness' is most likely to be achieved via an emphasis on quality.

6. ISOLATION

Taxonomic and systematic researchers in institutions too often operate in isolation from the wide range of relevant work in HEIs. There would be major benefits if there were much greater contact between them, and if those in institutions were more involved in teaching and collaborative research with staff in HEIs. Some steps are now being taken to erode the tradition of isolationism.

Traditional systematics is perceived as resistant to innovation. For example, most workers could make fuller and better use of modern data-handling techniques. The present old-fashioned image of systematic biology would be improved if those involved were seen more readily and enthusiastically to be embracing change. We strongly recommend that staff in our national bodies concerned with taxonomy or systematics should be seconded for periods to work at major institutions overseas to broaden their outlook and learn about other ways of going about their work.

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7. PROFESSIONAL TRAINING

The professional training of people in taxonomy and systematic biology is best undertaken at postgraduate level, building on broader biological skills and interests developed during undergraduate studies. It is advantageous for the major taxonomic centres to participate actively in this process, for example through the mechanism of CASE Studentships. More opportunities are needed to stimulate the initial interest of sixth-formers and undergraduates in natural history, taxonomy and systematic biology.

8. PUBLIC AWARENESS

Historically, the importance of marketing and presentation in UK natural history institutions has until relatively recently been accorded limited recognition. In this respect there is much that might be and is now being learned from other countries. Institutions such as NHM and Kew have a key role to play in promoting public awareness of biological science, and its applications to current problems of agriculture, ecology, environment etc. As professional scientists, we welcome efforts to present science attractively and imaginatively.

9. SUMMARY

(i) Systematic biology is fundamental to much biological science.

(ii) The facilities in the UK for systematics research are of international importance. Ways should be found of sharing more actively with the international scientific community responsibility for financing, maintaining and exploiting them.

(iii) Systematics research in institutions should be financed through a process of competitive peer review that covers also other publicly funded research in this field. This could be achieved by establishment of a Systematic Biology Committee within the Research Council structure.

(iv) Greater interaction between staff in institutions and staff in other centres of systematic biology would be advantageous.

(v) Institutions such as NHM and Kew have a key role to play in promoting public awareness of biological science. We welcome efforts to present science attractively and imaginatively.

Examination of witnesses

PROFESSOR B K FOLLETT, Biological Secretary, PROFESSOR J L HARPER, Emeritus Professor of Botany, University of Wales, PROFESSOR J MAYNARD SMITH, Emeritus Professor of Biology, University of Sussex and MR A J LEANEY, Science Policy Section, The Royal Society, called in and examined.

Chairman

369. Good morning, gentlemen. Thank you very much for coming and also thank you for your submission which I think we have all found very helpful. You also will have had from us a list of possible questions and there are two ways of beginning this encounter. One is that you might like to make a general statement and perhaps deal with some of the questions which have been sent to you. The other is that you might like to go straight into discussion. You will know better than me what is the best way to proceed.

(*Professor Follett*) Thank you, Lord Dainton. I think I will make a very brief opening statement which I hope will draw your Lordships' attention to the nature of the committee we have put together and the subjects that we cover. Our evidence was prepared by a committee chaired by Professor John Harper, who is with us today. It contains biological expertise drawn entirely from biological fellows. None of them however—and that was the intention—are taxonomists although all of them are users of taxonomy and in a very proper sense of the word are systematic biologists. One of the committee members, Professor John Maynard Smith, is with us this morning. I think you Lordships would rather spend time talking to Professor Harper and Professor Maynard Smith about the various areas which you have raised in your questions but I would like to stress the main issues which were brought out in our

report. First of all, the United Kingdom for historical reasons, has a particular interest and skill in taxonomy. Secondly the Royal Society, as is every one involved in allocating scientific resources, is most concerned about the question of how one determines rationally the volume of systematic research which you should undertake in a country and how does one ensure its quality and volume—and quality we see as particularly important. For most disciplines—not for all but for most—this occurs through the rigours of the research grant process and the support of the individual investigator. So that sets standards and also to a degree from competition sets the volume of research that can be sustained in a given area. In so far as systematic biology is concerned it applies to most of the scientific fellows involved in systematics, but not to the museums funded by other means, and they are affected by the cold winds of the research council system. Thirdly we raise the possibility of international funding. That is a point that you may wish to come back to. We are particularly keen, I think, to raise the question of whether the Natural History Museum or comparable organisations can be viewed as European or world resources. I think as you will see, we are rather interested in the European dimension particularly. Fourthly, we raise and Professor Harper will elaborate on the issue of what one means by curation and research and whether you can draw the line between these. The feeling is you probably can in the same sense as you can draw a line

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[Continued]

[Chairman contd.]

between teaching and research within the university structure, something we are now doing in an accounting sense. The last thing is we are concerned—and that will come out and we would like to get to that—about the isolation of the museum collections and of the full-time researchers from the universities who have a teaching research function and where most of the young people are located. Finally, a minor but in our view a non-trivial issue, is we should become concerned with living collections, particularly algal collections and certain herbaria. That is not an opening into London Zoo but it is an issue on the collections which are held on a strictly scientific basis. That is the basis of our report.

370. Thank you very much. Did you want to say something, Professor Harper?

(Professor Harper) I would prefer to answer questions.

371. We were very interested in what you said, of course, about the unusually large United Kingdom interest in this particular field because of its collections and because of the history and also your remarks about how one maintains quality as well as quantity. I think you said there was a problem that the research councils' tests of quality only applied to universities but not, I think, to those doing this kind of work elsewhere. What surprises me in the light of what you have just said is I think you also said the diverse arrangements for funding for these non-university bodies does not appear to work too badly. Are you content with it or do you see ways in which it might be improved? You do propose a strategic approach to the whole thing through a committee.

(Professor Harper) At some stage in the past your Lordships formed the Morton Agreement which produced an answer in one of the very oddest divisions of responsibility, with part of the flora world and parts of the world's flora for Kew and other parts for the British Museum, which involves a most extraordinary division. Kew's responsibility stops short of Columbia and the British Museum's starts there and the British Museum's responsibility goes down to the tip of North Africa and does not go further. There are these very very odd geographical distinctions. The British Museum handles ferns but Kew does not have the responsibility. On the face of it it looks so crazy that it could not possibly work but in practice, I believe, for both organisations, it seems to work perfectly happily by mutual agreement and annual meetings. The Scots come into this picture in the same way with an annual meeting ensuring there is no serious overlap. I think I certainly, and some of my colleagues, feel this is a model for a trans-European division of resources and responsibilities and could be very usefully explored and would solve some of our problems of manning the very very large collections and curations that we have. Amongst the questions which your Lordships posed was one which implied that the collections went to areas in which could they could not be properly and safely looked after. This was not in our minds at all. It would have been tragic to place the collections in Iraq, for example, but we would see no difficulty in arranging for a division of responsibilities like that between the British Museum and Kew extending to

Zurich, Berlin and other countries across Europe to great advantage to everybody.

372. Yes, I can see that, and I am sure we all can, and of course there is a great deal of sense in resisting restitution of cultural property where, when it is restored to its country, it is not properly looked after and not made available, and there are advantages for scientists to have a lot of material in one place. What I was trying to get at was the problem which those institutions which are not universities suffer from when their funds are provided by other bodies, whether MAFF or the Office of Arts and Libraries, and what effect that has on research in this particular field. Is there a need, which is what I thought your Committee was getting at, for an over-view on the field of research in this country? It was stated in your evidence, I think.

(Professor Maynard Smith) I think we had a feeling that something needs shaking up, if you like, in the state of systematic research in this country. I think we do feel that the big advances which have been made in systematics, both in computer methods and biological methods and the reclassification of major groups of organisms, have not happened here. I think there has to be a reason for this and it has to do with the isolation of museums from the mainstream of British academic life. So it is partly a question of making closer links between the universities and the museums. If you go to America there is a museum at Harvard, there is a museum at Missouri, and there is a museum at Berkeley, and all three museums are worked in and there is a real collaboration between the systematists and the university scientists. The other thing which we thought would stimulate research in this area was the clear recognition that people from the Museum and Kew should expect to have to apply to research councils for support for their research, if what they want to do is not curatorial but fundamental research. However, at the same time that requires the research councils recognise first of all their right to do so and secondly the importance of research in this area, otherwise it will not work. But something has to be done to shake things up a little.

373. Two things which are happening at the Natural History Museum at the moment will carry your approval. One is, as we saw, the association of Imperial College and a 50 per cent appointment funded by them and 50 per cent by spending his time the Museum between the two institutions. The other equally activity was their right since 1987 to apply to research councils and for the tests to apply, to which Professor Follett referred.

(Professor Maynard Smith) I am sure we do agree with these things, and yet I do not think that very many applications have been made, have they? I do not know.

374. We are trying to get the figures from the Museum as to how much money was got from these sources. I think the worry is that the activity is so dispersed between the Museum on the one hand and the universities and other bodies on the other, that there is no coherence in the sense of policy.

(Professor Maynard Smith) I would also welcome the fact they have established at the BM a molecular

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[Continued]

[Chairman contd.]

biology lab and the chap in charge is a lively chap, trying to get collaboration with various university departments. I think it needs more encouragement and probably more institutional help to make it happen.

375. The Royal Society did in fact suggest some way in which an over-view could be taken.

(*Professor Follett*) I certainly would concur with the point Professor Maynard Smith has made. We need a livelier approach and one has to take the fact that the United Kingdom has historically made a great contribution to this subject. It is an open question whether the United Kingdom is at the cutting edge right now. Within the whole area of taxonomy and systematics, the country must be investing a considerable sum of money. There are still a very large number of academics who undertake taxonomic research scattered around biology departments in this country, and in some geology departments there are two or three individuals. I have to say they are usually individuals who are more interested in the group of animals or plants than in the broad subject, but those people link into the British Museum and Kew rather well on the whole. Certainly personal experience at Bristol suggests our people are regularly up at Kew, perhaps once every two weeks or three weeks, collecting material. I think that interconnection is very important. The view I think we would have overall is that that structure, which in some ways is in place, which is an informal structure, should now be taken forward rather more actively. Therefore we come back to this issue of the isolation of the scientists within the Natural History Museum—and I cannot speak for Kew—from the main academic mainstream. They have very few graduate students or links with graduate students, and we all know the power of youth in science as distinct from that of old age. I think we would like to see that, and in many ways we would like to see the Museum take the lead, the directors, in setting up inter-disciplinary meetings, acting as a focus, as an engine for developing systematic biology. Very much systematic biology is the relationship between organisms and evolutionary biology; the use of molecular biology in this way acting as a focus for courses. There was some talk in one of your questions about whether we should have formal masters' degrees. I think our committee felt probably not, but what would be very good would be two or three month training courses during the summer vacations perhaps for graduate students in methods of modern classification, in the use of molecular biology, which would draw together graduate students from across Europe. Many of us, and some of your Lordships, have taught on these courses, and I am off teaching one in a month on a biology class. Extremely valuable for a variety of reasons. However it seems to many of us that the systematic biology community has quite a considerable amount of resources at their disposal and they could do many of the things your Lordships' Committee may recommend them to do in the end.

376. They should be doing it but you suggest they need a focus for it?

(*Professor Follett*) I think they need a focus. If you look, as an example, at the issue of grants at the

British Museum, I do not think you will find there are very many grants at the moment. But this is a cultural phenomenon, they have never had to raise a penny in their lives, most of them, in that sense; they are paid by the state to do curation and research. In the universities, as many of us can tell, you get paid your basic salary and then you obtain money elsewhere. I think it will take a lot to encourage them down this road. But it must be for the good of the British system, and it will also bring systematic biology more directly into the mainstream of the funding of biology and not, as it were, end up as a subject feeling under threat, feeling under-valued, a loss of self-esteem in some ways, and then, as it were, doing rather little about it except to try and complain that somehow they are being cut off. All academic disciplines go through the waxing and waning phases all the time, and I am sure systematic biology is only one of many. I can think of some on the physical sciences side which feel rather under-valued at the moment. But it does not seem to me the solution is to isolate them and put them in a box and treat them specially, so much as bringing them into the mainstream so we can attract into the subject clever young minds. There are plenty of clever young minds about. If one teaches biology, as the three of us do, we find the graduates are more stimulated by evolutionary biology and the interconnection between evolution and ecology than they were 40 years ago, and that in a very proper sense is within the remit of systematic biology.

377. But we were advised by some of our witnesses that there is only one university at the moment which at under-graduate level has any real systematics today, in the sense of courses on the animal kingdom in zoology.

(*Professor Follett*) I do not know about that. I am surprised anyone knows the detailed course structure of 50 biology degrees. I thought I knew a few. I would have thought there is still a considerable amount of systematics. Certainly it is taught in the School of Biology at Bristol and I would not think we were abnormal.

378. Did you say there is a lot taught in the schools?

(*Professor Follett*) Yes, I think there is in the School of Biology at Bristol University, which is where I come from—not as much as there was 25 years ago but then the subject has extended enormously in the last quarter of a century.

(*Professor Maynard Smith*) I think what this might reflect is that 30 or 40 years ago British departments of zoology and botany were right in the middle of the 19th century. Coming from engineering as an undergraduate, with Professor Sir Peter Medawar for goodness sake, who was an experimental zoologist, one year we studied vertebrates and the next year we studied invertebrates and then they had run out of information and we went back to vertebrates. So it is quite true. When I was setting up a course at the University of Sussex it was a blank piece of paper. The main thing in my mind was at least I was not going to do that. We settled it around the modern things like physiology and genetics and so on. We still teach systematic biology within it. I suspect what

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people were worrying about is we no longer have this tradition of teaching nothing but systematic biology in a very old-fashioned way. I think that is a jolly good thing. I think it would be disastrous to go back to what we were doing 20 or 30 years ago. What we need to do is teach evolution theory and teach the theory of taxonomy to some extent, which I was never taught. If I was to ask, "Why is this a palea?" I was told it is a matter of judgment almost. I am all in favour of courses that teach both the methods of taxonomy and the theory of taxonomy but we certainly do not want to go back to the 19th century stuff we were teaching in the old days.

379. To be fair, I do not think any of our witnesses wanted to do that. If we could go on to the problem of museums. The Royal Society was in receipt of a large number of protests about what is going on at the Natural History Museum and the concern that somehow research would be diminished in quality and volume by the changes that were proposed. What is being suggested by you, I think Professor Follett, is that they should be competing in order to maintain quality like the universities and a dual support system with the funding for the two gardens and for the Museum, which I suppose is what we are mainly talking about, would be providing them with well-founded laboratories and facilities if they are to play their part. Are you satisfied about that?

(Professor Follett) I think that the concept—for example, if one took the scientific staff at the Natural History Museum and put them on a sort of dual support structure whereby they got their basic salary and premises provided for them and then they went out and got funding, clearly has its origins in the university system which I think, despite disparagement in various quarters, has served this country very well in the last 40 years and has done equally so in the United States where it was developed. In so far as they have well-founded laboratories I think some of us are rather concerned about the state of the laboratories in the Natural History Museum. I know Professor Harper has recently visited one within the Museum.

(Professor Harper) I was rather shocked at the conditions in which research was being done. It was acceptable research but the approach to the laboratory was a bit like the approach of Edward I's cook at Conway Castle. It was a narrow winding staircase into a laboratory which was full of pipes running across the ceiling and where valuable pieces of equipment were hidden away in dusty corners. It was a question of whether it would really pass safety regulations. There was an escape path across the roof but the means of getting in and out was uncomfortable. This was an attempt to do first-class research under conditions which were really not appropriate in which to do it. I have only seen one section of these at Kew. The situation is a little different because there are new buildings being put up but these are being put up now to rectify a situation which was really quite appalling and a situation which would not be tolerated in most universities.

380. You would not regard it as the duty of the trustees to make good that well found base from which the scientists were working and making

applications so successfully to research councils for funds.

(Professor Harper) Or to link more closely with universities for the provision of some of the facilities.

381. That does not necessarily mean a neighbouring university.

(Professor Harper) It could be whatever is the most convenient. The Natural History Museum and Imperial are the most naturally linked although in many ways it could be elsewhere. For Kew, Reading and Oxford are the most appropriate.

(Professor Follett) Certainly one hears indicators. It so happens that one of my colleagues at Bristol wrote to me some views on taxonomy uses and uses of the Museum. I will read a bit of his note on it, "Over the last few years I have visited a number of museums throughout the world, to examine their collections. While they all bemoan staff shortages, I have noted in the USA such desirable features as air-conditioned storage areas, mechanically movable shelf bays to maximize space, personal computers and often laser printers for all researchers, collections data-based, with print-outs immediately available", etc etc. Then he goes on to say basically at the Museum "in contrast there are none of the material advantages listed above (apart from a few microcomputers), and my impression is that the magnitude of research done has been affected." These are semi-subjective observations but we cannot really expect our colleagues in the Natural History Museum and Kew to undertake innovative research unless we do provide them with good facilities.

(Professor Harper) It seems to me that the degree of isolation that is experienced in practice by the taxonomist adds to this problem. They do not spend periods working in comparable institutions elsewhere and they therefore do not know what the conditions are in, for example, a comparable US lab. One of the things I feel most strongly about is something equivalent to a sabbatical leave system to ensure our staff did spend six months or a year working with colleagues in conditions where they could see how the operation was conducted in a different way. They could have some idea of the variety of ways that things are done and they would not be simply pickling in lab conditions. I feel this is really very crucial.

Lord Flowers

382. Could I ask Professor Harper—he mentioned the Natural History Museum and people going to the United States to work with their opposite numbers—is he sure their opposite numbers in the United States, taxonomists in museums like that, are substantially better off and have better premises and are better looked after than they are in the Natural History Museum?

(Professor Harper) Certainly in the areas I know about. I am sure this is true for Professor Maynard Smith.

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Chairman

383. This raises an interesting point, I think. What you have been making a plea for is better resourced research laboratories in close contact on the one hand with the collections and on the other hand with the world outside. Is that right?

(*Professor Harper*) That is right.

384. That of course calls for financial resources, does it not, to be put in and this brings us back to the point of since these collections have world significance of how they are to be funded, since the United Kingdom alone looks as if they would not be prepared to be funding on the scale which is commensurate with their importance. Is that right?

(*Professor Harper*) I think what we are saying is if you take the magnitude of our collections, providing the human and other resources that would be appropriate for exploiting them fully, and you did not provide extra money for it then it would twist and distort the balance of our research. Although the collections are United Kingdom collections which have been made through our long colonial history and have enormous power because of this, their use is an international use and it is not clear that we should have our own research programmes biased in order to satisfy the international need.

Lord Flowers

385. I am rather puzzled by one feature that seems to have emerged. The Natural History Museum, in principle, can apply to the research councils for grants—whether they have done or not I am not sure but they can. If they were to do so the research councils could, in coming to a conclusion about the proposal, ask themselves whether the facilities they have available and the experience of the staff they have available are such that one could assume that the research will have a successful outcome. That, after all, is what they do when they look at an application from the universities—does it come from a well-founded institution? Supposing they found against the Natural History Museum, because that place is not set up to do research, so Professor Harper has said. That would mean even though they can in principle get a grant from such councils, they would not.

(*Professor Harper*) Please, I said they were not set up to do certain types of research. The laboratories that I saw were attempting to do some molecular biology and some culture work which they were not suited to do. In some areas, like the herbarium work, there was no question they were fitted out to do that, but in other areas the facilities were not appropriate.

386. Would they be likely to get support for this kind of science, which on the whole research councils are possibly not interested in?

(*Professor Follett*) I would have thought they are. I do not see the state of the laboratories in the museums as being that serious that it would stop them getting grants. I would have thought the research grants system would consider them well-founded or reasonably well-founded. Whether they would get funding, I think would just be down to the quality of the application.

(*Professor Harper*) I am sure also some of the laboratories would be considered very well founded for certain types of programme. Others would be

looked at and told this was not the case. There are certainly areas which involve the major herbariums—the main storage facilities and the collections—where I would not argue the conditions were bad in any way, but for attempts which are made to bring museum activities closer to the cutting edge of modern biology, I think they are struggling under conditions which are not appropriate.

(*Professor Follett*) One scheme where some of these thoughts were produced a few years ago was in relation to the AFRC and that somehow they were isolated, and the AFRC produced a scheme called “AFRC Link Grants” which were specifically intentioned. I have to say when one looks back, and Lord Selborne is probably more experienced than I am in this, one would say they have been very successful at pulling people out of their institutions into universities and also pulling people out of universities into a rather more disciplined structure to undertake research in research institutions. Something like that might be a possibility.

Chairman

387. Yes, I understand that. Returning to the question of dual support, the logic of what has been said is that in fact the museums are not sufficiently well-founded, and if one were to follow the pattern which takes place in universities, then money could be transferred to research councils to meet some of the indirect costs which are obviously not being provided. Have I understood it correctly? Is that right?

(*Professor Harper*) I think you could see other ways of coping with this problem. It involves links with universities where there are special research facilities which are needed, and it could be the most economic way for a museum to undertake this research is by placing its staff within a university department or research station. This seems to be, in many cases, the most appropriate way of doing it rather than duplicating large sets of facilities.

388. But most of the people on the staff are involved in curation as well.

(*Professor Harper*) Many of them are, and that would mean a university close at hand would be favoured.

389. They have to maintain that duty. Is it possible, do you think, to have good curation without research on the collections themselves?

(*Professor Harper*) We have talked about this quite a lot and this is a question of semantics and what you define as research. Because there is a sense in which, when one rings up Post Office telephone enquiries, you are asking for a piece of research to be done. Without in any sense this being pejorative, there are roles which a curator has which are comparable to that, where pieces of research are asked for and he searches for an answer. It requires that he has great wisdom, knowledge and access to and ways of retrieving this information. It does not imply that he is going to produce work which will be published in original scientific journals. I am sure there are many areas in which the act of curation does not involve doing pieces of original work which would lead to a publication on which you would then award the man a citation. Whether, when one sends a specimen to a museum and an individual curator

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spends several weeks trying to identify it—it may turn out to be something new or old—that is regarded as research is a semantic question. Whether a curator not being challenged by this would be a bad curator, and whether you would regard the curator who spends his time brilliantly solving these questions is not doing his job as a curator, I think is wrong. I think it is a false question you are asking.

Lord Porter of Luddenham

390. I just wanted to follow up two points about the isolation of taxonomists and the fact our taxonomists do not see the nice laboratories abroad and so on. Are you saying that this is a British characteristic or a taxonomic characteristic? Is it a characteristic of taxonomy throughout the world? Do the American taxonomists come to us? I was under the impression, from the 550 letters which we received which were of course very international indeed, that practically every museum and taxonomic laboratory in the world knew of our Natural History Museum particularly, had visited it and knew our people individually. So is this isolation of taxonomy a British characteristic?

(*Professor Harper*) I have a limited number of contacts with people who come to the British Museum and Kew from overseas and they come on sabbatical leave, some for a couple of weeks or a month, some for a year, and use the resources which are presently at the British Museum for their research activities. They are coming on grants from home or coming on salaries as part of sabbatical leave arrangements. When I ask this question of many of the British Museum or Garden staff, they say, "Yes, we do go overseas, we go overseas and collect, we go overseas and spend time on collecting expeditions", but this is different from the experience of those working in the New York Botanical Garden or the Missouri Botanical Garden, two of the great institutions in the United States. How material is curated, how questions are handled and how data is properly handled by modern data enabling system, how data is received quickly—these are the areas where our people do not get a picture of what the world is like. There is a tendency for people here to say, "We are the best, people do not go elsewhere."

391. I am sure the Royal Society grants for travelling fellows would be available for these sort of people. I assume there are not many applications.

(*Professor Follett*) I do not think they would be available because they are civil servants.

392. Is the problem one of funding in that case?

(*Professor Follett*) I would not add the problem is partly one of funding as with the provision of well-found laboratories. Actually to put one's finger on the biggest single problem which is facing the whole system, not just taxonomy, it is how do you distribute a limited volume of resources between staff, support staff, laboratories and travel. I think it would be fair to say on the whole in the United Kingdom we tended to put staff above everything in the 1960s and 1970s, and in many ways the 1980s have been a struggle to come to terms with the fact we have got a lot of staff. You can raise very serious questions as to whether the distribution of resources is quite right within the

museums or, I may say, within many universities between current grants and the salary line. We are coming rather close to an important issue which is political, which is, should the British Museum and Natural History Museum have more money and, if so, at whose expense? Or should it be told it will have to work within this particular volume of cash but distribute its money in a rather more creative fashion?

393. I ought to have known this but I am a little shocked by the fact that Royal Society fellowships and so on are only available to people in universities.

(*Professor Follett*) University research fellowships were given to us.

394. I was thinking more of exchanges.

(*Professor Follett*) They would be open to the exchange fellowship programme but that, of course, excludes North America. They are not, I believe, eligible for our research travel grants.

395. You feel that there is a gap here?

(*Professor Follett*) There is a gap. In a sense it applies to all employees in any research council institution. The same applies to a MRC or AFRC institute. I do not think we would necessarily encourage opening up our small research travel grants to all permanent civil servants.

Lord Selborne

396. Can I turn to the status of systematic biological research. I think you have made a strong case first of all for making sure there are well-founded laboratories to which research workers have access. You have made a case in your paper that such research as may be required should be driven by scientific needs, presumably where knowledge is inadequate or where it will underpin further branches of biological research. You have also made the case there should be a greater attempt to have cooperation on an international basis. Clearly we cannot spread resources too widely. You made a very strong case for encouraging taxonomists to take a more innovative approach. You have hinted that some of the problems were of their own making. Your response seems to be to encourage them to apply to the research councils more frequently for more grants. Does this not really amount to a case for an overview of systematic biology where some greater direction of research requires there to be some central organisation or body?

(*Professor Follett*) The planning route.

(*Professor Harper*) A biological research council.

397. I think in your paper you suggested there should be a sub group of one of the research councils or ABRC.

(*Professor Follett*) I think that suggestion was made, sir, because there is a danger in subjects that may perhaps have marginally lost some self-confidence that they will be squeezed on to the edges of all of the research councils dealing with this area and one route one could imagine the ABRC could contemplate experimenting with is they could look at this under the revisions of the ABRC. We thought that it was going to be more pro-active as a body in

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trying to bridge between the various disciplines of the research councils.

Lord Flowers

398. If I could just interrupt. Some years ago the ABRC did a study about the state of taxonomy and did conclude it needed beefing up. What happened.

(*Professor Follett*) I cannot answer that question, sir. What I do think is—

399. Professor Maynard Smith and Professor Harper must be acutely aware of what happened.

(*Professor Maynard Smith*) I am totally unaware of what happened.

400. Precisely!

(*Professor Maynard Smith*) I think very little.

Chairman

401. I was chairman successively of the CS of ABRC in those days and later a trustee of the Natural History Museum. This was partly a manifestation of the disregard of taxonomy in that time, partly because people had not realised the power and the shot in the arm given to it by modern molecular methods and partly because data handling had not got to a stage where it could be used. Would you agree?

(*Professor Maynard Smith*) I think it is a reflection of something that may have appeared when I spoke early. Disciplines like molecular biology and neurobiology had been in a sense struggling to establish themselves against a background of British teaching about systematic biology. There was a good deal of hostility to this "old-fashioned stuff". "Why should we bother with it?" I think for that reason grant applications or applications for research in systematic areas—indeed for whole organism biology—were not always looked at very sympathetically. I am sure that attitude is still around but I do think it is weaker now very much for the reasons you have just mentioned. The new methods of systematic biology made all sorts of interesting questions answerable which previously were not answerable, particularly molecular ones. I personally have no strong feelings about what the best way of doing this is but I think it was at the back of our minds that some positive discrimination in favour of systematic biology may be necessary—not as a permanent feature of funding but as a temporary feature of funding—if we are to overcome what is a temporary consequences of the arising of new disciplines and their hostility to the old ones.

Lord Butterworth

402. Your actual proposal for a systematic biology committee does foresee, even if it is only temporary, that it should be given funds to allocate, does it not? Have I understood that correctly?

(*Professor Maynard Smith*) Yes, it would have to have funds.

(*Professor Follett*) Some allocation.

403. Where would those funds come from? Do you foresee the AFRC or the SERC actually surrendering existing funds in order to bring this new committee into existence?

(*Professor Follett*) I am not sure I necessarily see people having to give up money *per se*; that seems to be quite a difficulty with individual research councils. However, I certainly see the idea of this committee as pulling together all the systematic biology research which is currently being funded in the various research councils and trying to produce some umbrella and seeing whether there is some structure to it. I think one is less concerned in some respects about systematic biology *per se* than taxonomy. Systematic biology is a very thriving business in this country, some of our brightest young people who are elected into the Royal Society are in this area, and I do not actually worry. I do not hear great cries of "under-funding" from my colleagues who have worked in evolutionary biology or ecology, behavioural molecular biology, the use of molecular biology—all the things which have arisen out of basic taxonomy. What I am afraid the problem is, is the value of taxonomy—finding money and spending money on reclassifying a particular group of Indo-Pacific fishes. That is a taxonomic problem and it is rather difficult to make that wholly innovative science. The very base of that work is what turns a taxonomic problem into a very fine piece of evolutionary biology, but it is a real problem of taxonomy.

Chairman

404. But it also coincides at the present time with increased demand. The case for biological diversity, the industrial application of taxonomy seemed, according to some of our witnesses, to be growing and they are finding there is an inability to meet that demand.

(*Professor Follett*) There are two questions there. First of all there is a service requirement. There is a demand for more individual organisms to be identified, but there is a separate issue which is in many ways at the heart of it which is, as a result of changes in fishery patterns in the Pacific, do you need to spend money re-classifying a particular group of economically important fishes in that area? That is the sort of research based strictly on the taxonomic collections.

Lord Walton of Detchant

405. Following up the point which was made about the proposed committee on systematic biology, your idea would be that this would have representatives upon which whose interests lay in the fields of each of the existing research councils; that would be the intention, I assume? Presumably you would be expecting it to be funded at least through the ABRC mechanism? One thing we have heard from various witnesses, which came to those of us not working in the field as a surprise, was that there a relatively small proportion of organisms, animals and plants have been classified and a very large number which have not yet been classified; this evidence came from several taxonomists. That of course brought to our attention one or two very important practical consequences, for instance—with my interest in medicine—the evidence that it was one very small strain of anopheles mosquito which was responsible for the transmission of indigenous malaria in the

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United Kingdom. So there are practical consequences. Do you see any prospect of international collaboration leading to internationally agreed data bases in the taxonomic field? If there is such a prospect, who should take the initiative?

(Professor Harper) There is such a plan for what is called Species Plantarum, in which Kew is the prime mover with other botanical gardens in the world. It is at a fairly early stage at the moment, but this is specifically the task it is setting itself, as I understand it. On the animal side, I would not know.

406. Just to follow up that point: you were very anxious to see preserved collections of living animals and plants, and you mentioned that in your earlier evidence. Does this wish extend right across the microbiological field in relation to collections of micro-organisms and so on and, again, where in the United Kingdom should this be done and, again, under what arrangement or initiative?

(Professor Maynard Smith) I suspect you have asked a question about which we have no knowledge. There are collections of micro-organisms, none of which is what people claim they are when you take them out of the pot and study them, but who is responsible for these micro-organisms. You are asking the wrong people, sorry.

(Professor Follett) It seems to me type culture collections—I am trying to put it on a concrete scientific basis. We did have a very good algal and protozoan collection housed in Cambridge funded by a long term grant from NERC. That has certainly suffered in the 1980s but I do not believe the collection has been broken up. I believe it was sent elsewhere and housed on a care and maintenance basis with little research going on. There is no doubt so far as active collections, such as the American type culture collection, which many of us use in molecular biology, that is very widely used and is, in fact, supported by the NHI which from my understanding is largely self-financing.

407. There is the Public Health Laboratory Service Reference Laboratory at Colindale. I think their collection is pretty limited to species or organisms which have a direct medical connotation.

(Professor Follett) It does seem to me to be something which ought to be organised on a worldwide basis. It is an FAO or WHO problem. I get my own samples from ATCC and Bethesda and there are no problems with samples.

Chairman

408. One of the problems which was raised in your paper right at the beginning (namely, that the collections which we have are disproportionately important in relation to the status of the United Kingdom as it now is), is the suggestion has been one should seek international funding given the envelope—as I think Professor Follett expressed it—of funding where you do not want to see the divisions running between becoming distorted, more money going in this particular direction. Have you got any positive suggestions about how that might be funded?

(Professor Harper) If I can say, one thing we must not forget is that there has been historically a major change in the way the taxonomy has been done. Forty years ago I wanted to find all the insects that lived in buttercup flowers and ate their leaves. This involved a lot of correspondence with specialists on the vast number of groups of insects. I was not an entomologist and these turned out not to be specialists from universities but were isolated clergymen, retired army generals, lots and lots of curious British taxonomists and specialists.

409. Members of this House perhaps!

(Professor Harper) Indeed, not in that case curious, Sir. But, it was very remarkable it was a curiously British state of affairs, there was nothing comparable in other countries. These were many of the people who worked overseas or in the colonial service who had become passionately interested in birds or beetles and they had become world specialists. That group has disappeared very, very fast and now the taxonomy is being left to professionals who are not necessarily doing the job any better but are required to be paid to do it. Our collections were matched by the people who used them.

410. It leaves a problem still?

(Professor Harper) Yes, it does leave a problem but it is a big historical switch in the place taxonomy occupies in the British scene.

Lord Flowers

411. Could I ask if one followed this idea of asking other countries to contribute to our collections, when there are bugs or whatever from other countries, if you carry that to its possible logical conclusion and you say: "If they are not prepared to pay we will throw them away", what would you have to say to that proposition?

(Professor Maynard Smith) I think we are stuck with them, are we not? I do not think we can or should throw them away. This is the price we pay for having been an imperial power all that time. We have got them and cannot ditch them.

412. It may need a stronger case than just saying that.

(Professor Maynard Smith) They are of international value. They are of very considerable value to the Third World because most of the organisms come from the Third World. In some senses the British Museum could be seen as something which could be funded by the ODA. I am not for one moment suggesting that it should. I think we have to see it as a responsibility we have inherited, we cannot just throw it away. This is a valuable responsibility.

413. I would like to follow up your mention of the ODA because it seems logical that the ODA can best help some countries by maintaining those collections which are of direct relevance to their needs at the present time. Is that a possible approach?

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(Professor Maynard Smith) It is a possible approach. It sounds just like saying: "Well, let anybody pay for it except me" and that is really not what I am wanting to say.

Lord Porter of Luddenham

414. On the international business: you, the Royal Society, perhaps get some information about this from the National Academy of Sciences or indeed other academies. I think you will be meeting them, will you not, next month or the month after?

(Professor Follett) We will meet them in September.

415. In September. What would their attitude be, they are a powerful body influencing the Americans?

(Professor Follett) Lord Porter makes a very good point. It is particularly pertinent because as I pointed out to Lord Dainton, when we met before this, Dr Peter Raven (who is an officer of the National Academy and is a director of the Missouri Botanical Gardens) is the person who I think you can raise it with and we hope to see him and certainly discuss it further. I know he feels very strongly—to go back to an earlier point—about this because he had a post-doctoral research period here at the Museum.

Lord Flowers

416. What would be the effect on British science or the British ability to earn its living by doing work for other countries? However you wish to look at it what would be the effect if the various parts of our collections were no longer available? It seems to me one has to answer that question in a very firm way if one is to convince Government it is worth their paying to look after something which may not be seen to have anything to do with us.

(Professor Harper) I think one would have to say in present financial circumstances one would have to cut the amount of research being done on the collections in order to keep the curation going. This would be the national responsibility, this would be the fallback position. It is difficult to imagine circumstances in which we would say: "We will not take any responsibility for collections we cannot let other people look after." We will have to do that or cut back on other research to ensure this is possible.

(Professor Maynard Smith) It will not have very much effect on British science. It will have a disastrous effect on the developing world. I do not believe any responsible Government can take a decision which says: "To hell with the developing world, we are alright." That is the honest answer. It will not have an effect on British science.

Chairman

417. On the Department of the Environment—following Mr Christopher Patten's speech last year—having a one day conference on the question of biological diversity which would seem to me to constitute quite a useful opportunity, the importance they attach to it is of such a high order by saying: "Well you cannot look at this without having a secure base of knowledge here", is that right?

(Professor Maynard Smith) That is right, yes, that is absolutely right.

(Professor Harper) You will find it interesting when you meet with Peter Raven of the National Academy, the director of the Missouri Botanical Gardens, if you ask him about his funding and research facilities. He persuaded the State of Missouri to build in a fixed proportion under the State budget for the support of his Gardens and their research.

418. This is not an argument for Scottish devolution.

(Professor Harper) This is how that big massive Garden and its resources are funded.

419. Yes.

(Professor Follett) May I just say something on a point which Lord Walton raised earlier, which relates to your point about the strains of anopheles and mosquitoes. I think that very much is the kind of thing I was concerned about and the research which was very taxonomical in nature. In principle one sees absolutely no problem with that sort of research being funded, it is genuinely innovative and if it is necessary to classify groups of organisms for clear medium term purposes then I would have thought the research councils would not object to that funding of that research if it is of that sort of quality.

420. I wonder if you can tell us anything about the Australian biological resources study?

(Professor Follett) No, Sir.

421. Has that come to the notice of the Royal Society?

(Professor Follett) No, Sir, I am afraid it has not.

422. We will have to apply to them directly. I wonder if my colleagues have any other questions to put? Are there any other points you would like to raise which we have not touched on which you think we should be made aware of? Anything else Professor Follett?

(Professor Follett) I do not think so, Sir. I think we have covered most of the questions you were going to raise with us. No, I think the one area we are quite interested in is to encourage the discussions to occur not just in this island but to take on a European dimension.

423. Yes, it is also having an American impact. The American Museum of Natural History is likely to set up its own enquiry very shortly. I gather there is a great deal of concern there.

(Professor Follett) It is so easy to move now around Europe, as convenient as moving around this island, that one would hope we would start to have a European dimension. One of my colleagues, a diatom taxonomist botanist at my own university, has just moved to become the head of the Diatom Centre in Hamburg. That is excellent in many, many

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PROFESSOR J MAYNARD SMITH AND MR A J LEANEY

[Continued

[Chairman contd.]

ways. That will probably be the number one European centre for diatoms. There is nothing wrong with that, it is only an hour and a half's flight.

Lord Flowers

424. There is the Flora Europaea?

(*Professor Follett*) Whilst trying to encourage the systematists to work in this country I hope they can think across Europe.

Chairman

425. Is there a role here for the European Science Foundation?

(*Professor Follett*) I brought with me their latest volume, I was unable to look at it. I would hope so. You have experts on your Committee who can answer that better than I can.

Chairman] May I thank you very much indeed for coming and thank you for your submission.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 4 June 1991

THE LINNEAN SOCIETY

Professor J G Hawkes and Dr J C Marsden

THE SYSTEMATICS ASSOCIATION

Dr S Blackmore

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TUESDAY 4 JUNE 1991

Present:

Adrian, L.	Selborne, E.
Cranbrook, E.	Walton of Detchant, L.
Dainton, L. (Chairman)	Whaddon, L.
Nicol, B.	
Porter of Luddenham, L.	

Memorandum by the Linnean Society already published in HL Paper 41, ISBN 010 404 1919

Examination of Witnesses

PROFESSOR J G HAWKES, President Elect and DR J C MARSDEN, Linnean Society, called in and examined.

Chairman

425. Good morning, Professor Hawkes and Dr Marsden. Thank you both very much for coming, and thank you too for your very clear and succinct written evidence with certain dire warnings interspersed throughout it. May we also thank you for arranging the meeting, not on our behalf but on your own behalf, but I am sure some of us would be interested to go to it on 11th July at the Royal Society. It seems to me we are traversing a lot of the points we shall be interested in. I do not know whether you would like to make a general statement yourself to begin with, or whether you would like to proceed directly to the questions? Since you did direct your answers specifically to the questions, I suspect you may wish to make some general remarks as well?

(*Professor Hawkes*) If I may, Sir, yes. I am speaking partly, as you know, as the newly elected president of the Linnean Society, and partly as a career systematist who retired nearly nine years ago but still continues research in this discipline. As my predecessor, Professor Claridge mentioned with me in our report, submitted to The Clerk on 28th March this year, the main aim of the Linnean Society is to encourage the study of biological diversity in all aspects. Thus research in systematic biology is central to our interests, though we are also very much concerned with the science of ecology and especially the conservation of biological diversity throughout the whole planet. I and the Linnean Society strongly believe biological systematics is not only a scientific discipline in its own right but forms a framework into which other biological disciplines can be accommodated.

At one level systematic biology (or taxonomy, as it is often called) comprises the description and classification of biological organisms, also providing keys to their identification, and figures and diagrams as well. This is often spoken of as alpha-taxonomy, the beginning of taxonomy, and in fact it began, if I might go back in history, with the Greeks two millennia ago. Proper naming and scientific description began in the 16th and 17th centuries by herbalists, such as our own very famous and well-known John Gerard, but the foundations of 19th and 20th century systematic biology certainly began with Linnaeus some 240 years ago, whose collections we have the honour to hold in the Society's rooms. After

Darwin's theory of evolution in the 19th century, systematics began to classify groups in a way that supposedly indicated their evolutionary relationships. This was largely to begin with inspired guesswork concerning the major groups of organisms, but had a much stronger basis of factual reasoning in the classification of smaller groupings.

Later, in the 20s and 30s of this century, the sub-discipline of experimental taxonomy grew up. This used experimental techniques such as genetics, cytology (the study of chromosomes) the crossability and the fertility or otherwise of hybrids if they are obtainable, chemical studies, serology and other methods of elucidating systematic relationships in smaller groups. These methods were fine for groups of living organisms especially plants—and certainly on animals too—but they could not be applied to dead materials, or so we thought at the time. These experimental methods we believe were clearly just as “hard” a science as biochemistry, chemistry and physics; yet they relate very closely to the essential systematic work of collecting, naming and describing biological organisms, and to the studies of plant and animal communities in their natural environments (ecology) as well as the study of their present and past distribution (biogeography).

Modern molecular methods, which can sometimes be used with fossil material as well as living organisms, have recently added a completely new dimension to our studies of systematics and evolutionary relationships. Particularly with plants, chloroplast DNA studies are opening up new vistas in our understanding of evolutionary relationships which help enormously with classification. All these methods are particularly valuable from an economic viewpoint, as we mentioned in our first letter. If I may branch off for a moment, the work that interests me, mostly crop plants and their wild relatives—wheat, barley, rye, maize and potatoes (I have been involved with potatoes for many years)—these studies help plant breeders to clarify their results obtained from pest and pathogen resistance testing, and to set these results into a taxonomic or biosystematic framework, and make informed choices of material for further studies. They also form a basis for the scientific conservation of crop plants, which has been very much in the news in the last ten years or so, and the wild relatives of these as a source of breeding material for the years to come. As I said, I have been a

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[Continued]

[Chairman contd.]

potato breeder and taxonomist, and still am, and can give many examples of the importance of a taxonomic framework to help put into order results of the screening of that material for its economic value for breeders to use now and in the future. It also greatly helps the directors of what are called gene banks, seed banks, or tissue culture banks, where living seeds or living tissue cultures are stored and where the results of systematic evaluation must be entered into computerised data bases to form a system for the ordering of the information which comes from screening and other work, and thus to help evaluate the living collections in the seed and tissue culture banks. So we are certain that without the science of systematics or taxonomy, molecular biologists would find it difficult to interpret their results. I know this from personal experience, since I frequently receive requests from those working on potatoes, asking me to interpret their results for them and to suggest new meaningful future work.

Thus, to sum up, I would like to make the following points: 1. Basic or alpha-biosystematics as carried out in museums, institutes, botanical gardens and universities are an essential part of science, since they provide a foundation and a framework by which all other biological disciplines can be evaluated and understood. 2. Systematic biology in the wide sense provides us with a knowledge of new drugs, new economic products and the genetic diversity of plant species essential to horticulture, agriculture and food production today and will go on doing so in the future. 3. Systematic biology also helps us to understand the evolutionary and biological relationships between organisms and to collate and interpret results from other biological disciplines. We feel strongly that without a continuing supply of experts in the field of systematic biology many or indeed most results from molecular biology would be very difficult to interpret. This is my personal experience. 4. In particular, systematic biology is an essential basis in attempts to conserve the fast disappearing natural ecosystems of forests, savannas, deserts and oceans. In short, we must know *what* to preserve in order to understand *how* to preserve. 5. We well know that expert scientists in the field of systematic biology are a diminishing resource. This is due to a variety of causes of which your Lordships are well aware. However, at the risk of repeating the same arguments, I hope you will allow me to set out my own views very briefly on this subject. It seems to me that the main reasons for the decrease the training and employment of systematic biologists are as follows. First of all, swingeing funding cuts in museums and biological institutes; secondly similar cuts in university budgets; and thirdly the replacement of systematic biologists by others in what are deemed to be more "fashionable" scientific disciplines, such as biochemistry and molecular biology. Fourthly, the replacement of scientific curatorship of collections, that is to say curation by scientists working on them, by care and maintenance curatorship, to the detriment of scientific research. Fifthly, the lack of job prospects in systematic biology for young scientists when choosing their careers is due largely to the funding cuts just mentioned. If young people see that there is no future for them, no jobs for them, they do not take

an interest, their interests are switched elsewhere. Sixthly, the problem in obtaining research grants, possibly due to the fact that the grant awarding committees are mainly composed of members of other scientific disciplines and in a period such as we are going through now of financial stringency funding requests for biosystematics tend to be passed by. Finally, one has to say, the quite unjustifiable concept in some quarters that systematic biology is dull, old fashioned and unscientific, which we would not agree with, of course, Sir. This is my opinion and the opinion of Fellows of the Linnean Society of London by and large that systematic biology is an intellectually active scientific discipline, fundamental to other biological disciplines, which could and should be playing a more important role in evolutionary studies and the conservation of biological diversity if it were funded better and given the support and consideration it deserves. Thank you very much.

426. Thank you very much, Professor Hawkes. I do not think you will find us unconvinced that in order to understand animals and plants they have first to be classified nor that if you want to relate their properties to their ultimate origin that must be linked to the genetic material they contain. It is in a sense that coming together also with the fact that computers can handle a large amount of data which would seem to make a situation in which this whole field is ripe for high activity paradoxically yet at the same time you say in several of your paragraphs—and you have just said yourself again now—that the area is in fact not funded adequately. It is short of people and it seems to have a low status. Is that fair comment?

(Professor Hawkes) Yes, Sir.

427. How does one get from here to the desirable there within the envelope of what you yourself said was rather reduced funding? How does one make the case?

(Professor Hawkes) I think we should try and make the case for better support from the research councils, the Royal Society and any other funding bodies that have the money and are disposing of the money, equalising to some extent the funding for systematic biology with other disciplines rather than maintaining an imbalance as I see it.

428. Some people have represented to us that we have a special responsibility in this country because of the collections which are housed here which have more than a national or regional significance and it has also been suggested that perhaps one might find funds from sources other than the rather limited funds which are available here. Has the Linnean Society thought about this possibility?

(Professor Hawkes) We have thought about this and certainly if funding can be obtained from the EEC or other international bodies this is fine, but I think we really need a good solid basis from this country to help train biosystematists, promote their work and then the rest will come. However, if we do not have a sufficiently good basis of excellent trained biosystematists, which is what we are beginning to lack now, the age levels are increasing, people retire like myself—I am not going to last forever, and

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[Continued]

[Chairman contd.]

others are in the same situation—the newer ones are not being trained because of lack of funding. Once you have these people then funding requests can be made more obvious to other organisations and funding bodies outside this country.

429. Are you saying that one really ought to start at an earlier level?

(Professor Hawkes) Yes.

430. So as to create people who are able to compete for funds?

(Professor Hawkes) Yes.

Lord Adrian

431. I was going to take this point up and say my own impression is that although I am perfectly prepared to agree with you along with a lot of other scientific activities the recent years have been years of cuts in resources for systematics, I have the impression there was before that happened, even in the 1960s and 1970s, a feeling amongst systematists that they were not holding their own in the activities in the biological sciences. I am wondering whether there is not something rather more fundamental here. The question I want to ask is why do you think the biological community as a whole was not enthusiastic about systematics at a time when funding was in fact quite generous in the 1960s and 1970s? Further than that, is it not a possibility the people that the systematists ought to be persuading are the biological community, particularly in universities, who seem to have ceased to teach very much systematics and this is a different explanation for the present position of systematics. I wondered what you feel about it and whether you think there is any justification in what I am suggesting?

(Professor Hawkes) I think to some extent, yes. If I may mention my own situation: when I went to Birmingham first I was appointed as a lecturer in taxonomy. There was a post then—this was in 1952—for lectureship. This was upgraded in due course and I became a professor of plant taxonomy but then when I was given the departmental headship, the lectureship in taxonomy was withdrawn and the university would not give us one back. This is very bad I think.

432. Did your biological colleagues press extremely hard

(Professor Hawkes) We did.

433. --- for that position?

(Professor Hawkes) We did but without success. I think really that one of the problems was that we were already finding the cold winds blowing even in the 1960s and 1970s. Take the Royal Society: there are very few taxonomists or biosystematists in the Royal Society. When grants are given out then there tend to be no systematists on the committees and so if there is only a limited amount of money then biosystematic research does not get done. They do not get the grants.

Lord Porter of Luddenham

434. Could I just ask which grants are you referring to when you talk about the Royal Society? Applications for what sort of grants?

(Professor Hawkes) The application for research grants.

435. I am still not quite clear what research grants the Royal Society provides, except for the recent very small ones, the small grant schemes?

(Professor Hawkes) Yes, those.

436. You would say systematists who apply do not get a fair deal?

(Professor Hawkes) I would say that, with respect to the Royal Society. The Royal Society is made up of committees naturally in giving out research grants, and I do not think there are enough biological systematists on those committees to give a fair judgment on this kind of request.

Lord Porter of Luddenham] I am very well aware of this difficulty, and there are other disciplines who would say the same thing. Very often there is only one, perhaps two, in that discipline to shout for it. I understand that.

Earl of Cranbrook

437. Chairman, I remember the 60s as being a period when university departments were re-organising themselves and re-thinking. It has been put to us by previous witnesses that systematics is the under-pinning of science and it may not actually appear clearly as a discipline. I wonder how many departments of English would stress the need for a lexicologist or a lexicographer, yet language is the under-pinning of all literature? It has been put to us that when the need arises, scientists in other fields will turn, when they are sorting out the systematic relationships of an organism that they are investigating, to systematics themselves and in turn become systematists in order to solve some of the problems which they may have approached as a physiologist or from some other direction. This might suggest it would be vain for us to seek to reinstate systematics as a clearly distinct discipline with a clearly distinct line of funding, but rather we should encourage its pursuit by scientists to back up their research in other fields. Is that a reasonable analysis?

(Professor Hawkes) I would not fully agree with you. I see the point you are making. The problem is that unless you have biosystematists in universities or in research institutes working on these groups, then you will not get the other people, the experimental people, the physiologists and biochemists, ever turning to solve their own problems in the way you suggest. They just do not do it. People come back, if they have that need, to biosystematics or systematic biology; they will go to systematists if systematists are there. If they are not there, it is left.

438. Is the work of systematics in a sense the development of comparison, and whatever tool you use you are "comparing" groups of organisms and examining their differences? In whatever field, whether you choose to be a haematologist or a physiologist, you are looking and classifying and this is in fact a common attribute of man and not something perhaps for which one needs to develop a hard core of experienced practitioners to back up other scientists?

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[Continued

[Earl of Cranbrook contd.]

(*Professor Hawkes*) My experience would not go along with what you are saying actually. I think if you are a biochemist you are doing some work on a particular aspect of biochemistry, you are not necessarily working in comparative biochemistry. We know comparative biochemists in Birmingham and they turn to systematic biologists to help them interpret their results, and that was the point I was trying to make, that molecular biologists get some results, they do not know how to interpret them, what they mean, and they come to us to ask us how to interpret them and for suggestions they should follow in the future. I find this very obviously applying.

Chairman

439. Would one draw the conclusion from that, that possibly the right way forward would be to brigade people together who were systematists in your terms and molecular biologists and all the other disciplines necessary and concentrate them? Would that be the case?

(*Professor Hawkes*) It might be a good idea if you have your systematists, but you come back to the basic question that we need more money or more facilities for training systematists. In museums of course, particularly looking at the whole collections, dealing with the original collections, looking at the diversity within species and between species to see how far this can be helpful in classification, this could give us knowledge of possible evolutionary pathways which can then be used and applied and agreed to, or negated by the more experimental scientists. So systematists themselves, as I was trying to show, and the experimental taxonomists, have done a very great deal in this, but they do it because they have good bases of systematic biology behind them and they know what questions to ask, what answers to get and if the answers are wrong, they go back to basic examinations of material and say, "Where did we go wrong?" It is a process of careful research and going back to the beginning again and looking at what is happening and so forth.

440. The great collections are concentrated in this country, are they not, so you are going to have a lot of systematists, whether you like it or not, linked with more systematic biologists. Is not the answer to link the newer technologies for dealing with these things with some of those working in the great collections?

(*Professor Hawkes*) I am sure that is one of the answers, yes, but not the only answer because we still need to train more systematic biologists.

Chairman] Yes, I can come back to that a little later.

Earl of Cranbrook

441. Chairman, we are circulating around question 2 on the list, and you seem to be leading me to ask the question whether or not Professor Hawkes sees systematists ultimately as being rather in the role of statisticians, let us say, in university departments, providing a very important and essential service and essential perspective because of their particular training, but nonetheless a service to other scientists in a broad sense?

(*Professor Hawkes*) I would not say that was the only function of a biological systematist.

442. No statistician would say that is his only function, but it is an important function in a department.

(*Professor Hawkes*) It is important, yes, to collate results from other disciplines together and give them meaningful analysis, indeed yes, but you still need to have systematists working in their own right and using the techniques such as I have mentioned and getting into molecular biology. There is an case in point: I have a colleague in the United States who is basically a plant systematist and he has now studied the results of the RFLP analysis work which is going on in various parts of the world, to analyse differences in the chloroplast genomes between these plants. He is a specialist in that in his own right, so he is not relying on someone else to produce information; he has gone one stage further, he has gone and grabbed the techniques and brought them back into systematics to the benefit of his discipline.

Baroness Nicol

443. You touched on it when you spoke of new methods, but I wonder whether the availability of computer data storage systems has in any way changed the level of expertise which is necessary? It enables a wider field of workers to have access to information and to collate it, and I would like to hear from you whether the full use of it has made any difference in your field?

(*Professor Hawkes*) I think more use is being made, possibly not full use, of data stores and recovery to enhance a wide experience plus the memory aspect by biosystematists. This has enabled biosystematists to benefit from computer data bases—otherwise all their information would be left on scraps of paper or card indexes—and so make better use of their wide experience. So they are coming very much into computer experiences and can obviously at some point, if they wish, make computer-aided classifications and computer-aided keys for identification. So that I think is an important aspect. They have taken this new technology of computer organisation into systematics.

444. And it has had an effect of making information more readily accessible?

(*Professor Hawkes*) Yes.

445. To a wider field?

(*Professor Hawkes*) I think so, yes.

Lord Whaddon

446. To what extent is the apparent slippage of systematics in the pecking order a British phenomenon and is it holding its place in the rest of the world?

(*Professor Hawkes*) I think it is holding its place very much more in the rest of Europe than it is here. I would not like to say quite why this is so. I think biosystematists, are more respected in the rest of Europe than in this country. I do not know what we have done about this, whether it is our fault or not.

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[Continued]

Chairman

447. We have evidence from Leiden in Holland. The Dutch have got their act together in this field and achieved thereby some kind of priority for this work which struck me as impressive for a small country.

(*Professor Hawkes*) They are spending a lot of money on this, yes.

448. Is there a possibility that the Community might go down that road to meet Lord Whaddon's point?

(*Professor Hawkes*) Yes. Exactly why it is more respected in other countries, I do not know. There is a certain amount of respect for systematic biologists here but not to the extent of the Government providing much better funding than it does at the moment. The Dutch and the Germans do far better and the French and the Spaniards are spending a very great deal of money even though they have much less money for biological research and training than we have.

Lord Porter of Luddenham

449. Could it be merely a comparative thing? You say the taxonomy is slipping in this country but the new branches of biology are branches in which this country has led for many years: genetics and microbiology. Perhaps it is a switch from one branch to another?

(*Professor Hawkes*) I think there is an imbalance in this country as compared with other countries in Europe. The United States has so much money that nearly everything gets funded through the National Science Foundation.

Earl of Cranbrook

450. Can I ask how Professor Hawkes would measure output in terms of national effort? Would we be able to look rather simply at the list of new names of organisms that were published in any one year and check the nationality of the authors? It would be quite an interesting sampling process to test the validity of these assumptions if it was a reasonable method of measuring output.

(*Professor Hawkes*) I should think it could be done for plants through the Index Kewensis Data Bank. The output in plants is one criterion but there are some taxonomists who love publishing new names and others who like killing them. So, I think there is more to it than that, with respect, and this is a question of the biological relationships between the species and the study of them their natural habitat, as well as the collection of living material. It is also important to attempt to make hybrids to see how far the parents are related to each other. There is a series of experimental techniques linked to alpha taxonomy, which forms the underpinning of the whole thing. I do not think one can, with respect, just look at how many new names are published.

Earl of Selbourne

451. With Professor Hawkes' particular interest in crop plants and wild relatives would he like to comment on the adequacy of our policy for maintaining national collections in such plants? Do we have a national policy?

(*Professor Hawkes*) We did not have one for quite a long time until the Prince of Wales became interested and then the Government changed its attitude a bit. We now have an excellent vegetable gene bank at Wellesbourne near Warwick. This was formerly very under-funded. The AFRC would not fund it at all to begin with and we had to get a grant from Oxfam to get it moving. AFRC then decided to support it somewhat, but now it is well supported through MAFF. There was formerly no national policy and even when every other European country had a policy, we had not. We now have one and we have a national representative from this country—I am sorry I cannot remember his name—from MAFF speaking for this country with other countries, not only European countries, on the policies which we hold for genetic conservation of crop plants and wild relatives. We have now very much more money at the Scottish Crop Research Institute—SCRI—allocated to the potato gene bank which I formed myself in 1939 and which had been languishing in Scotland with nothing much happening to it for quite a long time. Now there is quite a change. There are wheat genetic resources in Cambridge and so on. We are getting our act together. Although we were very much falling behind other European countries, such as Czechoslovakia and other Eastern countries, we now allocate much more money to genetic resources than formerly.

452. Do you believe the Ministry of Agriculture is acting as the lead Government agency for ensuring national collections of crop plants are being adequately curated?

(*Professor Hawkes*) That is what I understand now. I am not on any of their committees but this is what I understand.

Lord Walton of Detchant

453. We have had evidence from Sir John Burnett on behalf of the Co-ordinating Committee on Biological Recording on which your society is represented. Do you see in this new development the prospect of improving co-ordination in this field of activity and research and of acting as a kind of focus for developing or renewing interest in it? Could I follow this up by asking whether your Society is one of the contributing members which gives it financial support? Where does it get its funding from?

(*Dr Marsden*) Yes, Sir. We do because there is no money in the recording organisation to provide funds so we do fund our own delegate. We have attempted to ensure that delegate represents a number of biological societies. I think he represents four or five, and between us we fund him to go to these meetings.

454. Do you, as a Society, have any difficulty in maintaining your own collections which are clearly extremely valuable? Is this a financial problem to yourselves and do you have any opportunity for funding research yourself, however limited?

(*Professor Hawkes*) Yes, we do. We do maintain the collections which were made by Linnaeus himself and the research which goes on. We maintain the collections and we have a strong room with a temperature and humidity control which we finance and we also have an active research project in progress entitled "The Linnaean Plant Name Typification Project". This is funded by the Natural

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[Continued

[Lord Walton of Detchant contd.]

History Museum, the American National Science Foundation, the Missouri Botanical Garden and the Swedish Linnean Society as well as a grant from NATO. So we have gone round to get funding for that. I think that is an important research activity. Active research is going on in the Society's Linnaean collections and linked on to other collections from relevant museums and institutions.

Chairman

455. It has always seemed to me the late Professor Manton was a very good electron microscopist, she understood ultra structure and was a marvellous systematist. Would you agree?

(Professor Hawkes) Yes.

456. Those are the people we want.

(Professor Hawkes) Yes.

457. Such people are less likely to come forward now because the funding base is clearly insecure as demonstrated by the recent loss of staff in areas of expertise in the Natural History Museum. That is a serious situation, would you like to comment on it a bit? We have visited the Natural History Museum, they have given evidence. We are aware of the letters which came into the Royal Society. Is that, in the view of the Linnean Society, a situation which is bad and should be rectified in anyway?

(Professor Hawkes) Undoubtedly it is, yes. The Linnean Society would, certainly agree.

458. What would you wish to see done?

(Professor Hawkes) I would like to see more funding and the re-establishment of research posts which have been lost.

459. On the ground you cannot curate without doing research?

(Professor Hawkes) Yes, Sir.

460. As simple as that?

(Professor Hawkes) Yes. Just maintenance—keeping the alcohol bottles topped up and that sort of thing—is not enough. You have to have active researchers curating collections as well; people who have become experts in their own field, such as diatoms. I understand that the Natural History Museum diatom section has been closed down. What could be more necessary now, when we have the possibility of global warming, or maybe global cooling for all we know from the weather of these last few days? Diatoms are the indicators of climatic change and climatic stability and it is absolutely essential that work on these should continue, we think.

461. It is, I think, in this particular area that there is a good deal of concern that links should be made with other organisations nearby, like Imperial College. Would that seem a sensible thing to do?

(Professor Hawkes) Yes, because it would help to establish good links with universities where there is a lot of research, or should be a lot of research, going on—if there are still biological systematics people in those universities.

462. Coming back to the Natural History Museum, since 1987 it has been possible for its staff to apply for grants from the research councils, and

they have done so. However, some people take the view that the well-found laboratory which is characteristic of the dual support system between universities and the research councils is perhaps being eroded at the Natural History Museum at the present time. Would that be your view?

(Professor Hawkes) Yes.

463. So, in other words, you would also have to need to up-grade basic facilities?

(Professor Hawkes) I think that is undoubtedly so. You would need to up-grade basic facilities and get staff back into the sections where they were induced to take early retirement or to a section that was closed down on a care and maintenance basis. This is the death of a museum; you have to have people actively working.

464. How do you think that has come about? There was a time, fifteen years ago, when this situation was very much better, and then there was a change in the brigading of the Natural History Museum and it disappeared from the Department of Education and Science and went into the Office of Arts and Libraries. Do you think that had any influence?

(Professor Hawkes) It may well have. It seemed to me to be a bad move.

465. But you have no direct evidence of this?

(Professor Hawkes) The only evidence of that is that the funding base is very much smaller at the museum, for the kind of research that we think ought to go on and for the maintenance of the collections.

Earl of Cranbrook

466. Professor Hawkes emphasised just now the investment the Linnean Society has made in curating its Linnaeus collection, and following that tremendous investment in curation with the development of a temperature-controlled room, research is now possible on the collections. When we went round the Natural History Museum, I was very struck by the enormous job necessary for curation. This seemed to me in some senses to be an indictment of the pre-existing system, that perhaps scientists had been too intrigued by their science to pay sufficient attention to their job of curation. Certainly the collections we looked at were requiring vast amounts of preservative work in order to continue to function as a prime reference collection. Can you judge from the Linnean Society's experience roughly the amount of funds which need to be put into curation and the protection of specimens before that research becomes possible?

(Professor Hawkes) I would find it very difficult to answer just off-the-cuff on this one, but a study could be made. The Linnean collections of course are somewhat smaller, very much smaller, than the Natural History Museum's collections. We have all Linnaeus's pressed plant specimens and we have his collections of fish, shells, beetles and butterflies. No birds now, although there was a collection once. That is about it, I think. These have to be carefully looked at from time to time to make sure they are not becoming infested with insects. Our butterfly, moth and beetle collection, the insect collection, went to

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[Continued]

[Earl of Cranbrook contd.]

the British Museum at one time for curation because they have the expertise to do it there. I think we have got them back now, so far as I know. For that curation we have been helped by the Natural History Museum, but we have a very small problem compared with the enormous collections which the Natural History Museum possesses, which has made it in the past one of the best world collections anywhere available. Now we are getting extremely worried about it.

Lord Walton of Detchant

467. One area which arises from evidence we have received relates to the ornithological collection at Tring, the section of the Natural History Museum there. They said that researchers in their experience make the best curators, and there had been a recent tradition of recruiting curators totally untrained and unqualified, and in that situation their feeling was curation had thereby deteriorated. Had you learned of this policy and what is responsible for it?

(*Professor Hawkes*) Do I understand you correctly to say that they took in curators who were not trained scientists?

468. They said that, yes, that they were taking in unqualified staff, on the assumption they would receive the necessary training in-house.

(*Professor Hawkes*) That I did not know about.

469. I see. Is that something of which you are aware in other similar situations?

(*Professor Hawkes*) There are always gifted amateurs, and Kew and the Natural History Museum have taken quite a significant input of gifted amateurs who have trained themselves by learning at the bench. But there are a lot of others of course who would never move on to become scientists or anything of the sort, so I think this fact has to be taken in perspective.

Earl of Selborne

470. Would you accept the thesis which was propounded that a research worker is a better curator than a person who is only qualified to curate?

(*Professor Hawkes*) It depends very much on the person. If you are talking about care and maintenance curation, then possibly a good technician is the best person to look after that, because his science does not go any further. But curation in the sense of seeing what the collections are, what is needed, how they should be ordered and arranged, what sort of scientific work is concerned with them, then a trained systematist is the answer.

Lord Porter of Luddenham

471. On the same point, can I ask Professor Hawkes to follow up your question, Chairman, about the convenience and possible relationship between the Natural History Museum and the Imperial College, which does seem to me to answer a number of the problems we have been talking about, for example, training? We have just been talking about the necessity of having research associated with it. You cannot have it both ways, Professor. Several times you have said the staff has to be

increased at the Natural History Museum, and of course if the Imperial College is going to be involved it will need staff as well, but where would you put any new staff? Where would the emphasis in future best be in research? The curation would obviously have to be largely at the Natural History Museum but would it be best to have your main centres of research associated with teaching in the Imperial College, which is only a stone's throw from the material? Is that the way to go?

(*Professor Hawkes*) I would not like to say that was the only way to go, I think it is one very useful way of going, having people who teach the subject and research the subject also relating it to the Natural History Museum. But I think the Museum has to have people there as well, who are involved in the collections and interested or committed to do various kinds of research which in a university environment might not be considered the sort of thing that would lead to promotion. So I do not think it is an either/or situation, if I may say so. A similar sort of thing goes on at the Royal Botanical Gardens at Kew; they have a very strong relationship with Reading University and Reading people come to give lectures and courses to the student gardeners and are very much in contact with the research staff at Kew in the herbarium. I am talking mostly about the herbarium now which is more or less a museum similar to the Natural History Museum with its own collection of plants. They also have reciprocal arrangements for PhD supervision and studies of this sort so I think it has to be a balance between the two. I do not think it is a good idea to put all your eggs in one basket.

472. Nice to have more eggs to put in.

(*Professor Hawkes*) Let us hope for more eggs!

Earl of Cranbrook

473. May I go back to this question of whether or not a systematist is also the best curator? I start with the Linnean Society: I am a long standing Fellow and have been a life member for many years, therefore I remember the period when the Linnean Society made a large investment to safeguard its collections. My view is that this superb gesture of careful curatorship was not driven by these working on the collection. It was driven by the people who wanted to look after the collection there. That is one side of the coin. On the other side of the coin, in Suffolk we had a local gentleman who was a world expert at the Natural History Museum. He has been dead for many years now. In his particular group of insects, when he died, we discovered amongst his possessions (because he had so mistrusted the curatorship of others), a significant number of the collection of types of species he had described. I think that has been the tendency of some scientists to mistrust the system and the safety of their collections. Again, when we went round the Natural History Museum we saw very clearly the consequences of the decision which had been made by the scientists to stick brass pins into beetles. Anyone who had studied curation as a science might have been able to tell that there would be a chemical reaction between the interior of a beetle and brass, which would produce outgrowths which were damaging the specimens. I wonder whether

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[Continued

[Earl of Cranbrook contd.]

Professor Hawkes would insist it is investigative scientists who make the best curators?

(*Professor Hawkes*) I think the gifted technician is an important part of the whole process, but not by himself. I may say a lot of people feel they would like to keep all the specimens in their own cupboards and drawers, particularly those who do not want other colleagues muscling in on them. My own experience is that I put all my specimens of new potato species into Kew. I have a look at them now and again and find that they are excellently conserved. I do not have to put brass pins into them.

Chairman

474. You are making a case for a taxonomy of curators. If I could come back to the beginning, there is a serious question at issue: nobody seems to be really content with the situation as it is now. Everybody says not enough money is being provided and yet everybody wants peer review so you put yourself in competition with your fellow biologists for resources. How is this problem to be resolved in this country? Is it to be by seeking funds from elsewhere because of the international importance of some of the collections or is it for the scientific community as a whole to be involved in some examination of systematic biology as was suggested by the Natural Environmental Research Council? We, after all, are not in the position of being able to make an expert review yet I think—I speak only for myself here—we are convinced the situation is not as it should be in this country.

(*Professor Hawkes*) I think it would be very interesting and perhaps be a strong point to try to get information from our European partners to see what proportion of their national budget goes into museum and university research compared with us.

475. That would be comparing the different views of governments?

(*Professor Hawkes*) They do not like to be caught out.

476. I think we could brush that one off.

(*Professor Hawkes*) That is the only thing I can think of. I am convinced we do not get quite such a good deal as the Dutch Government are giving their scientists and biological systematists.

Lord Adrian

477. I am impressed by your apparent view that nothing can be done to make systematists more highly regarded in the biological community. It seems to me from what you have said from time to time you take the fact that it is low in the pecking order in biology as a given rather than something which might be changed? I am wondering whether I am interpreting you correctly? Do you have a number of things which you think might be done in systematics as a discipline to raise its status in the biological community?

(*Professor Hawkes*) I do not want you to go away with that sort of impression. I think that what we should do is to try and get more systematists and particularly biosystematists, that is experimental taxonomists, into university positions and to

promote the experimental aspects of the science which will impress our experimental colleagues very much more than the basic and necessary curation of large collections.

478. You think a priority in universities where biology is well represented would be either the changing of posts to posts in experimental systematics or the creation of new posts in experimental systematics?

(*Professor Hawkes*) I think that would be an excellent thing.

Lord Porter of Luddenham

479. Would experimental systematics include genetics, molecular biology and that sort of system? In a way are you not hanging on to this word "taxonomy" in a narrow sense when in fact the target has moved?

(*Professor Hawkes*) You are thinking the target is moving towards more biochemistry not molecular biology?

480. When you say categorically other countries do more research in taxonomy than we do, how would you define it? Would you include the genetic DNA taxonomy?

(*Professor Hawkes*) This is beginning to link on to the more conventional type of taxonomy I was trying to explain but, of course, whether you could convince people that was part of taxonomy at the moment, I doubt. If you take taxonomists who are experimentalists—and a number of them are—and if they could see careers looming forward in front of them, then very many more would joint this aspect of taxonomic research and give us more understanding of biological and evolutionary relationships.

481. It seems to me the taxonomist is hanging on to his career more than a physicist. A physicist is quite happy to be called not even a biophysicist but a molecular physicist but the taxonomist is not prepared to go over to the other side.

(*Professor Hawkes*) I think physicists are not so threatened.

Chairman

482. There is one question I must ask: the Linnean Society has done a survey, has it not, of teaching and research in universities and polytechnics? Can you tell us when that will be out? We should very much like to know the results of that survey.

(*Professor Hawkes*) The survey of taxonomy teaching and research in the United Kingdom is at an intermediate stage. We have the first draft and the university departments are still sending material. The survey is not yet complete but will be sent in due course, I hope in the not too distant future, quiteshortly.

483. Well, we hope to see the report. Thank you very much indeed for coming. Have we failed to cover any matters?

(*Professor Hawkes*) I do not think so.

Chairman] Thank you very much, Professor Hawkes and Dr Marsden for coming.

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[Continued]

Supplementary Memorandum by the Linnean Society

Status

1. Systematic Biology has suffered great losses, but not because of its excessive fragmentation; rather, because of competition with other more laboratory-based disciplines in biochemistry and molecular biology. It is undervalued (see Professor M. F. Claridge's and my report) through a misunderstanding of its basic importance as a foundation to all other biological disciplines.
2. See 1 above. It is a distinct scientific discipline (see my report).
3. "Amateurs" form a small but significant fraction, concerned mostly with alpha-taxonomy (not with experimental or laboratory-based studies); they are certainly fewer than 50 years ago.
4. Data storage and recovery have enhanced the "wide-experience-plus-memory" aspect of biosystematics, enabling biosystematists to benefit from computer data banks and so to make better use of their wide experience and understanding.
5. There are still large numbers of systematic papers carried in journals, possibly slightly increased, but decreased in proportion to those of other scientific disciplines.

University links

6. Collaborative links between universities and national institutes have decreased probably, due to the diminution of biosystematists both in universities and national institutes—also the difficulty in obtaining funding grants. Closer links could be effected by increasing the number of biosystematists and, particularly, research funding grants both in universities and national institutes.

Regional funding and priorities

7. The system of passing NERC taxonomic publication grant funding for administration by the Linnean Society is most valuable. This might be extended to cover research funding also. Perhaps SERC and Royal Society funding for biosystematic research might also be administered by the Linnean Society, or by some other independent body.
8. See 7 above. There is great competition for research funding in times of financial stress, as at present. Few committees have taxonomists on them and thus are less well able to evaluate taxonomic *versus* non-taxonomic research grant requests.
9. The Linnean Society Grants Committee can only give priority to systematics research in a very limited field through shortage of grant funding. Its policy is to support good research wherever possible according to clearly defined priorities, and it could play a more significant role in the future if more funds became available.
10. U.K. institutes (or those of any other countries) cannot possibly hope to maintain research collections and systematic expertise in all groups of organisms. Priorities are determined partly by the collections available, partly by perceived scientific or conservation needs, and, of course, by gifted individuals and the interests and expertise available in this country.
11. This is an extremely difficult question to answer. It would be better to try to restore the balance by providing more money overall and by reducing slightly the funds previously allocated to other disciplines, thus providing a better overall balance.
12. The *organisational* change I would advocate is to fund systematic biology research separately from other disciplines or to ensure that at least one systematic biologist was appointed to each relevant committee (see 7–9 above).

Training and courses

13. The problem here is lack of research funding *and* job prospects. A career structure with more posts available in museums, research institutes and universities concerned with systematic biology would have no difficulty in drawing students into this subject, in our view.

Linnean Society questions

14. Professor M. F. Claridge's report deals with this question.
15. Curation and research are indissolubly linked, if by curation we mean the arrangement and classification of such a collection. We have an active research project in progress entitled "The Linnean Plant Name Typification Project". This is funded by the Natural History Museum, the American National Science Foundation, the Missouri Botanical Garden, the Swedish Linnean Society and NATO. It involves active research on the Society's Linnean Collections and on others from relevant museums and institutes.

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It should be understood that if by "curation" we mean routine technical activities, such as repairing damage, writing labels and general maintenance, such activities can be undertaken by well-trained technicians.

16. Revisionary work on Flora Europaea is being integrated with European taxonomic expertise and at the appropriate time a European-wide funding initiative will be put forward.

Memorandum by the Systematics Association already published in HL Paper 41, ISBN 010 404 1919

Examination of Witness

DR S BLACKMORE, Botanical Secretary, the Systematics Association, called in and examined.

Chairman

484. Welcome, Dr Blackmore, to this meeting. I am sorry we kept you waiting but I noticed that you heard all the discussion and evidence before, so that you know that I am going to ask you obviously at the outset whether there is any general statement you want to make. In particular I would be grateful if you would deal with something I did not understand in your evidence which seemed to me possibly to be of some importance, which was the CITES Convention. Perhaps in your general statement you could explain that; it is a point which came up in section 2.3 and I am sure you know all about it. Perhaps you could also tell us why there is a Systematics Association and a Linnean Society because what you both deal with seems to be very similar.

A. Thank you very much, my Lord Chairman. I had intended to make a few general remarks but I am going to begin by saying in many ways Professor Hawkes has provided an ideal introduction for the subject and also for the Systematics Association. Interestingly enough, the Association was formed as a splinter group which split off from the Linnean Society in 1937 and was largely concerned perhaps with people who felt more an affinity with systematics, which some people distinguish from taxonomy and other aspects of biology the Linnean was involved in. In practice the two work increasingly closely together. I am a Fellow of the Linnean Society as well as Botanical Secretary of the Systematics Association and many people hold joint appointments on the two councils. So in practice they work more or less as one. I think it would be fair to say from time to time we have discussions on the possibilities of merging and effectively functioning as a single unit, which for many purposes we do. That was a specific but I think, as I say, Professor Hawkes has introduced many of the points I would raise and there are obviously strong similarities between the submissions of the two societies. I wanted to make one or two very brief points in general before attempting to answer your questions. I think the message I would like to get across is the fact that systematics is a subject with considerable urgency now and this is something which perhaps is not a situation previously recognised. I am referring specifically to the now widely recognised problems of global environmental change and also, in particular, the so-called biodiversity crisis, the accelerating rate of species extinction and habitat destruction. I think these are both issues which give considerable immediacy and relevance to systematics. I think the Association's view is that those are things they would like to emphasise. As Professor Hawkes pointed out, it is impossible to proceed to conserve anything until you know exactly what exists and where it is. Of

course, before we can make use of any living organisms, whether in agriculture or any other form of use, we need to know the properties, values and ideally the relationships of those organisms. It is interesting to think that estimates at present would put the percentage of species so far described as perhaps round about 7 or 10. This varies enormously, as I am sure you know, depending on what the overall projected estimate of species might be.

485. May I interrupt? The problem that worries me is, how, if you do not know them, can you estimate their magnitude?

A. I am a botanist and fortunately botanists can tell you with a reasonable degree of precision, based on the rate at which new species are being discovered in the tropics. There have been a number of papers summarising the rate of discovery and predicting the total number of species, in flowering plants probably well up into 90 percent of all species on earth having been described. People will dispute this to some extent; others give different figures. The real problem areas are in relation to groups such as nematode worms, fungi and most particularly insects where current estimates seem to be getting back down towards a more conservative figure—7 million seems to be popular at present. Nevertheless, there is a wide variation in the number of species people consider exist. One of the important consequences of this is in comparing taxonomy as a sort of infrastructure in biology with dictionaries, and it means at present the dictionary has many blank pages with a large number of organisms not even initially described and taken into consideration. I feel this is one urgent area in the systematics arena. I do not want to overemphasise the species number angle because I think that argument is overplayed in many areas. Then again, as I say, I am a botanist. You tend to find entomologists feel that is a real driving force increasing their priorities in their subject. The second point is that the Association feels very strongly that there is a great strength in systematics in the United Kingdom that stems partly from the very extensive collections and also historically important collections such as those of the Linnean Society but also from the associated libraries and, indeed, associated expertise that has been built up around these collections and resources. We do feel that that position has been eroded somewhat; nevertheless, I think the Association feels we are still very much a nation that can be seen as prominent in the field of systematics internationally and we want to take a relatively positive view of that. There is a lot of potential for us to contribute internationally in systematics. I should perhaps make an aside—a rather personal one which I had not planned to

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DR S BLACKMORE

[Continued]

[Chairman contd.]

make—which is that I had individual responsibility for decision-taking on diatoms, amongst other things, in the Natural History Museum and I think it is important to point out that the disappearance of the diatom section in name does not necessarily mean the disappearance of the science; that in fact we have more people working on diatoms now than previously did. The latest recruit started yesterday and is somebody who will be resuming the manufacture of diatom specimen slides. This person is 18 years old with no previous background in the subject. I am mentioning it because, in view of the earlier questioning on the issue, I feel you may like to return to it. So we are taking somebody with no background in diatom work at age 18 to begin training for what we hope will be a career diatomist. In the Natural History Museum but all in the same area of research we now have molecular biologists working jointly with the University of Bristol and we are doing, I would say, extremely innovative research on diatom systematics through the latest molecular techniques. We have five people in contrast to the three prior to reorganisation. So disappearance of sections by name does not always lead directly to the apparent disappearance of expertise. Since that was a very personal decision in consequence of my own position, I felt it worth dwelling on that at this point. Consequently, although I think there has been erosion in all sorts of expertise in the United Kingdom, still it is an extremely strong country.

486. Could we know your status? You speak with great knowledge of the Natural History Museum. Are you employed by the Museum?

A. I should have started out by explaining that I am here today as the Botanical Secretary of the Systematics Association but I am in fact the Keeper of Botany at the Natural History Museum and consequently responsible for decisions under the reorganisation of the department in the last 18 months or so. I am going to endeavour to speak from the Association's viewpoint today as much as that is possible. So we feel that in particular the importance that systematics has, its relevance in the world today, is in relation to important current issues such as sustaining the biosphere, understanding what is in it, its function, the importance of biodiversity and working towards the kind of understanding which will enable concepts such as sustainable development and land management to be a reality because we have an understanding of the organisms involved. We feel there are important concerns. If I turn to what we would like to see happen, it would perhaps primarily have a recognition of the importance of systematics to those issues. I think that is not sufficiently widely perceived. They are considered to be the domain of forestry or soil expertise or a range of others and traditional systematics is not going to bear on those problems. I think there is a new perception of systematists that is needed and there is a need for a connection between systematic expertise and immediate concerns such as those. Finally, a rather different point but again it relates to elements in the earlier discussion. I would like to emphasise the Systematics Association takes the view there is a tremendous amount already known about biology diversity but it exists in primary form in collections

and data not analysed and consistently not available at the drop of a hat, though questions are posed about a number of species in a certain area. There is a great need to begin to make the body of information that is available and exists something which is much more accessible to the scientist. I think this is an area where the computer has a great role to play and is an area which is beginning to take off now those opportunities are beginning to be realised. To summarise: we feel despite the difficulties the discipline is undoubtedly in, and not to play this down, we do nevertheless feel there is a tremendous amount of effort and it is something which is a strong United Kingdom area of expertise.

487. Perhaps we can take up directly the question of the breadth of expertise. You have spoken rather more optimistically about what goes on in the field than the previous witnesses but you made the point in your Systematics Association evidence that there are areas in which we have no skill, none at all?

A. Yes.

488. Could you tell us what those are?

A. It is important to say first of all that when talking about groups, they should be groups at any level within the hierarchy from a kingdom down to an individual genus of organisms. One has to start by defining what scale one is going to look at this problem on. There are many areas in which we have never had expertise and we have never had comprehensive expertise across all organisms in this country, and that does not exist in the world, but nevertheless there are some groups where there could be an immediate scope for development. It is difficult in answering to give you a direct answer in naming groups because of the level one might choose to do it at. Many of the lower plant groups are relatively poorly understood and a particularly relevant one would be those groups of algae which grow out of water, for example, on trees and walls which are extremely sensitive organisms from the point of view of indicating pollution but which are very poorly understood. There has never been a detailed study of this in the United Kingdom and the expertise to carry this out does not exist.

489. Can that technique be acquired fairly quickly to meet demands or do you have to have a competence across the field in every sphere?

A. I do not believe you can hope to have competence in every sphere and I do believe you can acquire it relatively rapidly. For the fact there is incomplete coverage is not an issue I would have dwelt on quite as much as some of my colleagues who helped shape the Association's collective viewpoint. One could attempt to go on listing groups of organisms but I do not believe it would be constructive.

490. It is a matter of importance which could be tackled at the time it arises?

A. To some extent. The list could be endless. Within the nematodes, there are people working, there is a body of a dozen or so who have expertise in nematology. Given the size of that group I am absolutely certain, without knowing about the genera which exist, that many of them need an expert and many of the families have no expert. The

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[Continued]

[Chairman contd.]

problem is when there is an issue requiring an answer from nematology.

491. It is the pull of demand which helps as well as the push of science in getting attention on a particular area?

A. Yes, I think that is right.

492. You have heard what has passed before and the general tenor of the evidence is that perhaps the amount of resources which is going on British work in this area is less than it ought to be. Suggestions have been made we could seek funds elsewhere, have you any direct experience of how those funds might be sought, given the importance of those collections in the institutions and in Kew or Edinburgh?

A. I would answer that from experience in the Museum. A lot of money for systematic research is drawn in from overseas' resources. Currently we have several posts funded by the National Science Foundation in the Botany Department at the Museum. We have been relatively less successful in European funding efforts and I think there the problem seems to be the immense difficulty of getting through an incredibly elaborate bureaucratic system to arrive at sources of securing funding. There have been nuparticular initiatives or very few where taxonomy expertise was called for directly. Recently there have been several which concentrated on biodiversity so they create opportunities for taxonomy to apply in various aspects of biodiversity research but there have been few pockets of money to aim at. As yet I think there has been very little success in the past few years in really deriving substantial funding from Europe.

Baroness Nicol

493. Are you saying you have applied and been refused or have failed to find a mechanism?

A. Many people have applied and failed, of course there have been successes. To some extent this is a pattern for applications in grant funding in science, it is extremely competitive and success is not necessarily easy. Again, to give a Natural History Museum example, the zoological department co-ordinates a programme under the MAST programme from European Community funds but we have not yet had any other successes, although there are a number of applications being made at present. I think that pattern is true across other institutions. Relatively few have had success in finding funding from the European Community.

Earl of Cranbrook

494. I feel a little bit anxious about the eighteen year old who is going to spend an entire career sticking diatoms on to slides; will he or she develop higher curatorial expertise? The other question, from the point of view of a practising systematist within his career structure, is he or she capable of moving from group to group as needs appear on the broad scale, let us say across Classes?

A. I think the first point, you raised concern on this particular individual, we feel it is very important they have a generalised ability to curate botanical and other natural history species. They will not be working exclusively with diatoms, although in the

past they would have done so. We feel it is important to draw people out and also to develop a broader expertise. I think the answer is to some extent that one can transfer people quite widely between groups. We have done this in the Museum from time to time without enormous difficulty. One of the problems in taxonomy is that undoubtedly there is the opportunity to spend a lifetime becoming a very narrowly focused specialist, perhaps a world-class expert in a group, but at the same time there are opportunities for becoming quite broadly skilled in aspects such as label preparation, cataloguing of specimens, display of specimens, preparation of them, preservation work, and there are many broadly transferable skills in that whole area of curatorial work. I hope that answers the question, but I expect our 18-year-old will not spend the rest of life doing precisely the same task but will pick up a particular skill—and it is really quite a specialised one—making diatom microscope slides and also at the same time acquire the ability to work with more typical plant specimens mounted on to herbarium sheets which is what most of our work involves.

495. Can the research worker make similar shifts across Classes?

A. I think it is a difficult distinction to make. In some respects we now do distinguish in the Museum, again managerially, between people being members of the curation team or members of the research project team; nevertheless, research workers undertake a certain amount of curation and people in the curation team undertake a certain amount of research. The balance will depend on their particular abilities and on the work that is to hand and needs doing. For instance, our newly started diatomist will perhaps one day become someone who may well publish on diatoms but that is certainly not part of their immediate task. I think there is not such a distinct black and white line between curators and researchers; even though again names of sections may give the impression that people are divided rather rigidly in that way, their day-to-day jobs span both aspects of the subject.

Lord Walton of Detchant

496. Would someone like that, apart from working on the job, have the opportunity of day release for more academic study, for instance, in the interest of future career advancement?

A. They will have, yes. In fact, that is the tradition in terms of when we have recruited people who have perhaps A level qualifications and not higher. There have been opportunities for them to continue training and perhaps interestingly enough one example is a diatomist, somebody who came in, who had a master's degree and is currently registering for a doctorate and is now a well-known publisher in the field.

497. To come back for one moment to the factual point about your society, how many members have you roughly? What proportion would you say are university based and what proportion work in museums and what proportion in other fields? Is the number declining?

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DR S BLACKMORE

[Continued]

[Lord Walton of Detchant *contd.*]

A. We are a small society. We have, I think, 520 members at present, mostly in the United Kingdom but a small number internationally. They tend to have been participants in our symposia who joined when they were in the country. Some remain as members, others do not keep it up after the period of membership expires. So we are not large. The number is, in fact, growing only very slowly—we would like to see it grow more rapidly. But it increases, I think, in leaps and bounds when we have a particularly successful symposium, we may pick up 50 specialists in a certain field and add them into membership. I would find it difficult to give a really precise breakdown or balance between universities and, say, taxonomic institutions, but I think there is certainly a good mixture there. I think it is probably fifty-fifty between the two kinds of organisations if one can generalise.

Lord Adrian

498. I am puzzled to hear you pick up 50 experts you did not know about when you have a particularly interesting meeting. That seems to me to suggest that there is more activity in systematics than we are hearing about here. Maybe I have got it wrong.

A. I think what it really reflects is people's memberships of societies and we do not have all systematists amongst our numbers. Consequently it is still possible to have a very successful meeting and find a number of people who can be enticed into membership on that occasion. Normally they are people we certainly know of in the scientific community.

Chairman

499. Could I come back to the central point that has been made to us many times, namely, that there is a declining effort in the United Kingdom and part of this is due to a lack of resources and, therefore, the suggestion has been made that one should look for overseas sources of funds—we discussed that a moment ago. There are two points in connection with that. When you do get overseas funds do they bring with them the complete overheads or does it mean that a contract of that kind represents an earmarked demand on, for argument's sake, the Museum's own resources as well? Secondly, in view of the fact that in Europe the Framework Programme is meant to build for what is called social and intellectual cohesiveness, is that not a natural area to try and tap?

A. Well, as I say, there have been efforts in that European arena and just at present with relatively limited success. I certainly agree it is something we are pursuing extremely vigorously. I think that would be widely reflected in our members in universities or wherever they are; increasingly the grant sources people are looking to are the international funds. That tends to reflect the fact that perhaps the Research Councils here have not had; again, targeted pockets of money that would be in appropriate areas of research. I think that answers your second point.

500. The first one was overheads.

A. There we have a complete spectrum from sometimes having fully covered overheads and in other cases not. It almost varies point by point.

Certainly you can be successful in getting a grant and find what you then have to do is match very strongly from institutional funds. On the whole you still tend to regard that as success, nevertheless it is a burden.

501. Does your funding body, the Office of Arts and Libraries, recognise in your case the need for what used to be called in universities a well-found laboratory?

A. I think that is probably ideally a question for the Museum to attempt to answer, but—

502. As seen from the point of view if your members?

A. I am probably an unusual one of my members in terms of my views on the Museum, being rather close to that situation. I think under the Museum's funding body, the Office of Arts and Libraries, we may well have fared considerably better than we might have done under the Department of Education and Science. It is well worth noting that they clearly do not recognise fully adequately yet, although we are vigorously telling them, the need for secure funding, and I think in particular recognition of the effects that inflation of salary bills has on institutions like ours. This genuinely is something which is not just a Museum problem but one which faces institutes such as Kew and perhaps all publicly funded sciencebodies. So it is not a unique problem of the Museum.

503. You heard the question put to the previous witnesses about the suggestions that the field is in such a state that perhaps the Advisory Board for Research Councils or NERC ought to look into the general field of systematic biological research. What would your members feel about that?

A. I think that could certainly be extremely helpful, but, of course, one also knows that there have been a number of past ABRC inquiries into taxonomy which sadly did not lead to significant or conspicuous action in terms of sources of funding becoming available. So that may be a rather simple answer but I suspect it is perhaps the one many members of the Association would feel at present—that the Research Councils do not need to assess further the need—it has been well stated by many people; what is needed is funds to be there for applications to be targeted.

504. But when the previous inquiries and reports were made you were then under DES and science vote funding and the aim of those inquiries was, in a sense, to draw the attention of the trustees to the way in which they used their block grant. Was it the trustees who did not in fact develop the thrust of the recommendations of the report, are you saying?

A. I think that would be a very difficult one to try and answer. I was not in the Museum at the time of the previous ABRC report and I have no idea how it was received and implemented.

Lord Porter of Luddenham

505. May I ask about the interesting number, about 500 members of your Association, are those all, would you say, professional systematists, my first question? The second question would be what proportion of the total in the country do they

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DR S BLACKMORE

[Continued]

[Lord Porter of Luddenham contd.]

represent? Thirdly, what qualifications do they have in the way of degrees and in what subjects?

A. They are interesting questions. Most of them are in fact professionals or research students, I would say, but if you asked them if they were a systematist or not, they might not all answer yes. Many of them would regard themselves as being more specifically a palaeontologist or molecular biologist or whatever but in membership of the Systematics Association, they are looking to systematics for its central and synthesizing role. So it draws people who perhaps classify themselves as other specialists.

506. How many are graduates and what did they graduate in?

A. I am afraid I do not know sufficient detail to answer that. Many are biology graduates. As far as the officers and council members, who are perhaps the central core of the organisation goes, I think most of those are people who have undertaken research in systematics and many of them have doctorates in systematics. So, I could not put precise numbers on it. Also, I do not know what a satisfactory interpretation in the whole United Kingdom population of systematists would be. I could not extrapolate it from our membership. The great problem is identifying who they are.

507. We do talk about comparisons with other countries, we also talk about there not being enough but when one asks how many there are we do not get a complete answer.

A. I conducted on behalf of the Worldwide Fund for Nature a survey on tropical taxonomy, but talking of tropical taxonomy there is no difference between tropical taxonomy and temperate taxonomy. They were interested to know what the science base in the United Kingdom was. By surveys through a variety of institutions and by looking at material produced by many universities and other research institutions I did come up with a listing of what appeared to be all professional tropical taxonomists. That is a sample.

508. In this country?

A. Yes, this was United Kingdom based experts.

Lord Adrian

509. Would you think that too many, just about right or too few?

A. The sad thing about the report when we assembled it was that in fact many of them—we listed them because they insisted—are in fact retired though still work in the departments they were associated with and many more of them are very close to retirement. I think one of the problems is not whether the number is right or not; if you take for granted it is a reasonable level there is still a severe problem coming up through a lack of training of people through this area. My own view is it is far from adequate if you take the task the systematists should address being the biodiversity crisis.

Earl Selbourne

510. Could I ask about training needs? You drew attention to the lack of work at GCSE level, people going into higher education with no knowledge of

this area, how would your Association like to address this problem?

A. We have a number of people teaching in schools and a variety of other levels from primary schools through to secondary school science to higher education. They felt very strongly an understanding of whole organisms, their life cycles and basic biology, which is not perhaps a strict definition of systematics, has virtually evaporated from school level teaching and basic science in universities. This seems to be linked into the kind of teaching the systematist was doing. Their role was to provide a basic understanding of life forms and life cycles. That seems to have been moved out in favour of what we were hearing earlier described as more fashionable areas, ranging perhaps from ecology to physiology, or understanding processes at different kinds of level in biology. So there has been a change in emphasis there undoubtedly. I think to redress that, it really needs to start at school level and needs a building back in and understanding of what the diversity of life constitutes in terms of some form of study of the range of organisms and basic grasp of their relationships which is the starting point for moving into research in the field of systematics.

511. Can this subject be made interesting at GCSE level or A level? I think previous witnesses, eminent scientists, were very nearly put off by the generation of taxonomy of thirty or forty years ago.

A. I think that for every person who will tell you that I could provide you with a supply of people who will say they became absolutely hooked and regarded it as just about the most exciting scientific discipline and cannot understand why others have the misfortune of looking elsewhere in science. It can be made exciting. I think the important thing in systematics now must be addressing these important issues in the world essentially—it is very much a green subject, and consequently I think the link needs to be made with that enormous body of feeling for green issues that exists throughout society today at present. That has not been successfully achieved yet and certainly the Systematics Association sees part of its educational role now to be attempting to influence that, to make that connection in people's minds between understanding what there is in the world in terms of its biological richness and the kind of contemporary green issues that people are not only excited about but are prepared to put up funds in relation to.

Chairman

512. Dr Blackmore, in your Association's evidence a good deal of stress is laid upon the matter that is not a question of centralising resources but of getting co-operation as between different groupings. This is in section 2.7, I think. Are you suggesting there—I was not quite sure—that there should be some special financial provision made for collaborative ventures which bring together people from different institutions with different skills to tackle problems of systematic biological research?

A. Yes. Something that we have felt quite strongly in the Association is that those colleagues who are in university departments frequently feel quite isolated,

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[Continued]

[Chairman contd.]

they are not in amongst a body of experts in their own field.

513. Or collections?

A. In many cases collections on site. In fact, it is possible to do perfectly good research on a relatively small collection provided one has an appropriate collection, so there are many very successful people working without immediate access to a major systematic collection, but they feel increasingly isolated and we do feel quite strongly in the Association that one of the things which could perhaps be learned most clearly from practice in North America would be to involve the professional staff of taxonomic institutions much more closely in higher education and the universities and mechanisms for facilitating that would be extremely constructive, I think. It was interesting also, it occurs to me, that the previous discussion related to the proximity of Imperial College and the Natural History Museum. There is in fact currently one new joint funded palaeontology post in place and others are planned, as you may know, so certainly the Museum also sees that it has a potential role to give in this area and, as Professor Hawkes mentioned earlier on, Kew Gardens is also very closely involved in their research staff contributing to botanical teaching, particularly at the University of Reading. So there is a role for institutions, I think, in linking up much more—while they always collaborate on joint projects—in a concrete way in terms of joint appointments.

514. One final question: many people are being critical of what goes on in this country and you heard earlier, for example, in a small country like Holland they seem to do it well. Are there any other places we should look at which in your view, and those of your colleagues, you think are role models which might be copied for improvement of the situation here?

A. That is, in fact, a very difficult question, how to make a valid comparison. It is interesting historically

in the Netherlands, systematic botany has been very strong, some of the world's major herbaria are there. I would not like to say whether it was in other aspects: entomology or zoology. One reason it has survived so vigorously, they have had a strong tropical aspect related to their colonial past and traditions and their collections have great relevance today in relation to important issues in tropical vegetation. There are a number of historical factors, which are quite special there, as indeed there are in the United Kingdom. I think we can learn a lot from North America where the process of recognising the biodiversity crisis, to use that label, has translated itself into a science funding programme which supports inventory work. Other initiatives, initiatives in the computer data basing, have started to be supported in response to that crisis. There are lessons to be learnt there. If you look in Europe, in a variety of countries, including some which have fine systematic collections, they have long obtained their taxonomic expertise and there are many herbaria which are frequently visited because specialists want access to material which are in a condition of neglect. This was one of the reasons the Association felt, whereas we do not wish to deny the problems we and others perceive in systematics, nevertheless the United Kingdom does remain strong in this area.

515. I think we have probably asked all the questions we want. Are there any points we have not touched on which you would like to bring to our notice?

A. I realise I never did explain what CITES means, that is the Convention in Trade in Endangered Species and the body of legislation relating to endangered species. I think that clarification was one point.

Chairman] Thank you very much, Dr Blackmore, for coming.

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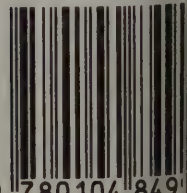
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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**
(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 11 June 1991

CAB INTERNATIONAL

Professor D J Greenland, Professor D L Hawksworth, Dr D J Greathead and Dr K M Harris

DEPARTMENT OF THE ENVIRONMENT

Dr D Fisk and Dr P J W Saunders

AUSTRALIAN NATIONAL PARKS AND WILDLIFE SERVICES

Dr P Bridgewater

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TUESDAY 11 JUNE 1991

Present:

Adrian, L.
Butterworth, L.
Cranbrook, E.
Dainton, L. (Chairman)
Flowers, L.

Porter of Luddenham, L.
Selborne, E.
Walton of Detchant, L.
Whaddon, L.

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Examination of witnesses

PROFESSOR D J GREENLAND, Director, Scientific Services, PROFESSOR D L HAWKSWORTH, Director of the International Mycological Institute, DR D J GREATHEAD, Director of the International Institute of Biological Control, and DR K M HARRIS, Director of the International Institute of Entomology, CAB International, called in and examined.

Chairman

516. Good morning. Thank you for coming and thank you too particularly, we all feel, for the very clear and crisp written evidence you have provided. I do not know whether you would like to make a general statement to begin with on points that have occurred to you that you would like to emphasise in your evidence, or whether you would like to go straight into the questions. You have already had a copy of some of the questions that we have thought of to put to you but there will be many others as well. Which would suit you?

(*Professor Greenland*) If I might first of all say we appreciate the opportunity to be here and to give you some of our comments. I would like to do two things fairly briefly. The first is to re-emphasise the disclaimer we put on the front of our papers about the views expressed. CAB International is an intergovernmental organisation and the Executive Council of Member Country representatives meets once a year, so for an opportunity like this we cannot make an official statement from the member Countries. We make it on our own behalf as scientists having a very prime interest in biosystematics in the United Kingdom and elsewhere. CABI has three institutes primarily concerned with biosystematics and taxonomy in general which have grown initially from the role of the Natural History Museum in the United Kingdom's international work, and we do have a very close linkage with the Natural History Museum, though no formal relationship with them. One of the questions that is on the question sheet sent to us and which we might have put into the paper should perhaps be mentioned right at the start. That is how CAB International is funded. We have a rather complex funding system. We were initially funded through the Colonial Office to provide identification services for agriculturalists working within the Empire. Over the course of the last seventy years or so the general funding arrangements have changed considerably. The provision of identification services, which was only part of our activities, grew into providing information about organisms and has now grown into a state where CAB International is the prime provider of information on agriculture worldwide through 40 different abstract journals covering the whole field.

That proved a profitable exercise. We were charged by the Member Governments to make it a profitable exercise and it has become so much so that it now provides most of our funding, something like £7 million a year. We generate another £4 million from our own activities in the scientific institutes, project work, consultancies and commissions, and a very small amount from identification work.

517. Is that net profits in both cases?

(*Professor Greenland*) Not net profits in both cases, total funding towards our operations. The profitable part is the information service and the profits that are of the order of about £2—£3 million a year, and that is the way our taxonomic work is funded. So essentially we are receiving a heavy subsidy for the taxonomic institutes through funds generated by our information services. The information services themselves feel we are tending to bleed them rather than enabling them to reinvest in their own activities, and it is a continuous strain within the organisation to balance those two demands. We do still receive some money from our member Governments. About 15 per cent of our total funding is in governmental contributions from all Member Governments, but we have agreed to decrease this further over the course of the next three years. What we do receive is largely a payment for the services we provide to our Member Governments, notably the identification of organisms as a free service for them and the supply of certain publications at nil or reduced prices. We have agreed that we will fade out the free services and fade in charges, but this will still only be a small part of our total funding. It is a little precarious. We are working partially on a commercial basis and thus it is not secure funding; certainly for the range of biosystematic and other basic work the base is pretty insecure. We have to earn a lot of the funding for the taxonomic work of the scientific institutes from applied projects.

518. Do you pay rent for the premises which you occupy at the Natural History Museum?

(*Professor Greenland*) No. The arrangement with the Natural History Museum is not on paper at all. We are occupying about half the entomology department at the Museum, the space is taken by our own scientists. We do not pay a rent for this, but the

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[Continued

[Chairman contd.]

appointment of our staff is usually done so that it is complementary to the Museum staff, so that the coverage between us is much broader than it might otherwise be. We also have provided, and continue to provide, a lot of material to the collections, and provide curation services for the collections. Although we have never had a formal agreement, we are in the process of trying to develop one. We have had a series of meetings with the Museum, and a joint committee was established from the beginning of this year to develop an agreement. So we are very much tenants, a little bit at the mercy of the Natural History Museum. We have therefore watched the recent changes there with a rather keen eye and have talked to them about how we might make the relationship with them firmer. This has extended beyond entomology to all areas where we might collaborate further with the Museum. We see this as a very positive move and are both hoping we will have an agreement to present to our respective Councils by the end of the year. If I might just add one other disclaimer, one of the submissions that has been sent to the Committee was copied to us by Mr Henry Barlow, of the Friends of the Museum, and it suggests that one option for the Museum might be to give charge of the collections and the taxonomic research to CAB International. That is certainly not what we see as a viable course that could be taken: (a) we could not afford it; and (b) we do not feel we are necessarily the most appropriate body. We have suggested in our paper that there should be a Board for Systematics, or something similar, established and we would hope that a Board such as that might be more appropriate and have broader interests than we represent within CAB International.

519. Do any of your colleagues want to add anything at this stage?

(*Professor Hawksworth*) If I could just say a word about how we see systematics in the United Kingdom at the present time. We feel the historical strengths in systematic biology in the United Kingdom have been in the production of authoritative and internationally acclaimed reference works. For this reason I think it is not entirely a coincidence that standard reference works such as the Index Kewensis, the Zoological Record, the Index of Fungi, and also the International Commission on Zoological Nomenclature, all have their activities based in the United Kingdom. Indeed, it is one of the reasons why the CAB International taxonomic institutes continue to be located in the United Kingdom. We have a system of visiting groups with outside representatives from different countries on them, and they repeatedly reaffirmed that our institutes should remain here because of the mutual advantages. We have a conviction that the United Kingdom has a key role to play in world science through providing such underpinning basic systematic reference works. World collections that the United Kingdom has obtained through history make a very substantial authoritative reference back-up, without which one cannot produce the critical world monographs, revisions and other compilations. We feel that this role should be strengthened so that the United Kingdom can play an increased contribution in international

programmes relating to biodiversity, genetic resources, and environmental conservation, but also in legislation aspects which are increasingly critical with respect to trade and endangered plants and animals, and also in regard to quarantine, organisms involved in food spoilage, poisoning, and so on. We are concerned that there may be some tendency for these traditional strengths to be eroded, and we do feel that there is a need to consider how this situation might be redressed. Therefore, we certainly think this particular select committee is very appropriate at this time.

520. Would you like to go directly to the questions. May I ask if there is anything you want to say on the questions which have been put in front of you, and those between 12 and 26 on the list, or shall we just try and work through them and others as well?

(*Professor Greenland*) I suggest we work through them, my Lord Chairman.

521. You have answered the question about the funding, but there is a second part to that question: do you have funds which can be devoted to supporting further systematic research? My impression from what you have said is that you are doubtful about that, and until you have negotiated arrangements which have financial implications satisfactorily you do not know where you stand financially?

(*Professor Greenland*) That is quite correct. We have considerable difficulty in managing the funding for our systematic work at the present time. It becomes stretched even more so each year.

Chairman] Perhaps we can move on to the next point and associate with that something else.

Lord Flowers

522. It does seem to me there is an implication if the CAB have come to the United Kingdom because of the taxonomic and similar facilities available here, and this of course is an international venture, why should they not pay for it, or pay for their share of it?

(*Professor Greenland*) I would not say we have come to the United Kingdom because of that. We grew out of what was here, because it arrived in the United Kingdom and the United Kingdom was the centre of the Empire at that time. The initial funding for the entomological work in 1909 was from the Colonial Office and the organisation has grown from that. I think over the years the United Kingdom has managed to divest itself of much of the financial load by making us, first of all, a Commonwealth institution and sharing the costs between the member governments, and then in more recent years by encouraging the movement into the commercial area for our publications work and, to some extent, for our scientific work. We have reduced the cost on the United Kingdom government in that way considerably over the years. The question at the moment that might be addressed is in two areas: both whether the Overseas Development Administration should take a more direct funding relationship to us, and we have discussed this quite extensively with them; and the other is with regard not only to funding from existing member governments, (28 of 29 are former Commonwealth governments, and Hungary

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[Continued]

[Lord Flowers contd.]

has become a member now that we have become international) but also non-members. There are about eight or nine countries with whom we are in detailed discussions about membership: Thailand, Indonesia, China, Czechoslovakia and several others. We expect that our funding and our relationship with them, particularly the sale of our services, will be promoted by having a much wider and broader membership more actively working in that way. I do not think the United Kingdom can or should try to escape its historical responsibilities because it holds the greatest collections in the world and naturally, I think, must remain the principal custodian of those.

523. From a purely Treasury point of view, the fact that we hold the biggest and best collection in the world is an embarrassment and not an asset. We are going to have to argue very strongly with the Treasury why we should carry that embarrassment. That is why I say to you, why do you not pay your fair share?

(Professor Hawksworth) If I could just come in here. I think we actually pay more than our fair share, because one has to recognise that if one did not have an International Mycological Institute, for example, the United Kingdom would have to fund one; and the United Kingdom would also have to fund a national fungus culture collection. This is another part of the equation which has to be taken into account. Further work done in my Institute is not done elsewhere in the United Kingdom; for example, the second biggest user of my Institute's identification service is the Ministry of Agriculture, because it does not have the staff capable of identifying the critical groups of pest organisms.

Chairman

524. Does it pay for those services?

(Professor Hawksworth) Only through the United Kingdom contribution. It gets them free of charge as part of its membership at the present time. As Professor Greenland pointed out, this is programmed to change in due course.

525. It does raise the important question as to whether, since you are dependent upon collections existing here, with their proper curation and the research that goes with that proper curation, in fact should there not be, as it were, a service charge on top of your service charge which recognises the use that you are making of this British resource?

(Professor Hawksworth) I think the point Professor Greenland was trying to make was that, in fact, the Museum has not had to employ as many entomologists, and it has not had to employ curators of the current collections, because a lot of that curation work and identification work has been handled through CABI employees. It is not a simple black and white situation.

526. Do your charges, for example, to country X, which may or may not be within the Commonwealth, have a surcharge in the form of a 10 per cent Rothschild surcharge in the early years of post-1972 to, as it were, subsidise basic research?

(Professor Hawksworth) No. The present charges are below economic cost in fact.

(Professor Greenland) To put it the other way, the charging at the moment is heavily subsidised, not by governmental contributions but by the profits, from the profits we make out of our information service work. I think I should also clarify the fact that of the collections used by us only the entomology collections at the Museum are held by the United Kingdom government. The fungal collections in the Mycological Institute are held at the Institute, and have been formed and developed by them, as have those of the Institute of Parasitology. We use our own materials, hold them, and curate our own materials.

Lord Porter of Luddenham

527. On those profits you have referred to several times that arise from your systematic research, how much of these come from attempts on systematic research?

(Professor Greenland) Minus about £3 million a year. The positive side is from the information products—abstract journals which cover the whole of the agricultural sciences. Although we provide free copies of that literature at the moment to each of the member countries, we sell the journals elsewhere in the world. What in effect happens is that the United States, our largest customer, Japan, Germany, and others who purchase those journals at a rate which is profitable to us, subsidise the taxonomic work, and that is where the major part of the subsidy comes from.

528. Is there a substantial income from taxonomic information nevertheless?

(Professor Greenland) No. The non-member countries are charged; it makes about £60,000 a year or about 2.5 per cent of the cost of running the institutes.

Chairman

529. It is very difficult for us to get an idea of these charges. At one point in your evidence, I think it was paragraph 9, you refer to the heavy penalty costs which arise from misidentification of a particular species, and one therefore wonders whether the price of correct identification should not also be marginally commensurate. What is the basis of your pricing policy?

(Professor Greenland) Roughly, what the market will bear is the answer, and what the market will bear is not very much. The greatest need and the greatest users of the service are developing countries and so what we can charge them is fairly limited.

Lord Flowers

530. Have you put your charges up to the point where they refuse to accept your services?

(Professor Greenland) We put them up to the point where the numbers of samples submitted has been declining steadily over the last seven or eight years.

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[Continued

Chairman

531. Are those developing countries receiving ODA assistance? Should they not be able to purchase this from you?

(*Professor Greenland*) Some of them are. We have initiated what we are calling a "partnership facility", four agencies to provide money for that purpose, amongst others. So far Australia and Canada have given us money for that. ODA at the moment is looking at it in terms of providing tied funding to specific countries or activities.

532. Would it be possible for you to give us a brief annual statement of your sources of funds? It would be helpful to us.

(*Professor Greenland*) We could certainly do that.

Lord Walton of Detchant

533. You have 29 Member Countries according to your submission. Are there any major developed countries which are not members and which might be recruited and might therefore improve your income?

(*Professor Greenland*) Yes. We are into discussions with several, Germany and the USA amongst others. The basis for their membership is something which is very much a matter of hard discussion because at the moment if they do become members then we have the problem that we will have to provide our services to them at a discounted rate similar to other members, and it would create a considerable imbalance at the moment in our funding unless we can find satisfactory arrangements with them about that. This aspect features largely in our discussions with them. Nevertheless we are hoping to expand our membership into other developed countries as well as developing countries. We have had some discussion with the Japanese as well on this basis.

Chairman

534. Perhaps we can proceed now to questions on the cause of concern at what you describe as the low level of systematic research in this country. How low is it? What would be required to put it right? Where do you see the major problems?

(*Professor Hawksworth*) We see the main causes, in fact, as changing government policies, with research institutes particularly looking towards short-term revenue generation. Research Councils we also see as being unable to support work on a traditional line. Competition for their grants is more competitive now and emphasises innovation, so revisionary work using established techniques tends not to be supported by SERC, for example. There are also problems in the perception of systematics, the image of systematics amongst people at all levels from students through to administrators, who do not necessarily see the relevance of the work, and we also feel that we have to be very careful with regard to the consequences because potentially one would run into this situation in the longer term whereby biological science will lose its mean of actually communicating all the information that it gains. All the information that is produced from applied as well as fundamental research work is linked to the names. If things are wrongly identified and confused, then the whole basis of the biological sciences starts to become unsure. I

think this has to be watched fairly carefully and, therefore, we view with concern the fact that one may be entering a situation where the United Kingdom does not have the specialist to provide the back-up to its own research workers in some areas. If some of the recent trends continue, this is going to be more and more of a problem.

535. This is a vicious circle, is it not, in a sense? The subject seems to be humdrum, not very fashionable though very necessary, and indeed there are other rather more glamorous bits such, for example, the relationship of genetic material for which it is absolutely essential to have the classification; and yet the subject is so relatively unpopular it is not followed with the same intensity at universities, and some universities do not have, we have been told, the staff and certainly this is reflected in the schools and in A level syllabuses where systematics is optional. Where does one begin to enter this particular circle in order to reverse the trend?

(*Professor Hawksworth*) My own instinct would be by much stronger links between existing research institutes and universities themselves in collaborative programmes. My own Institute is involved with collaborative programmes; and my sister institutes are involved with collaborative programmes with different universities in the United Kingdom already. This is a thing that can be enhanced by moving my Institute to a site being purchased from Royal Holloway and Bedford New College, next year. Professor Chaloner can elaborate on that if you wish; we hope for a lot more collaboration with them. We will be more involved in teaching and so on. I think this is one way to make students see that the subject can be interesting and is highly relevant. The other approach, of course, is that there should be actually funded positions through chairs, if there is a mechanism to do that, and so to make sure there are departments where systematics is a strength.

536. At least one witness has said to us, representing the other point of view, that you can learn what you need to know, if you are, for example, shall we say, a molecular geneticist or whatever, of systematics by being closely embedded with people working in that field. Is that true?

(*Professor Hawksworth*) Possibly, yes. It depends really very much on what people you are actually working with, and what problems they are looking at. If you are looking at a scenario of a range of variation in molecular work in a particular species or genus, it is not such a problem. If you are trying to work on overall classifications and so on it is more difficult. You then need contact with a wider range of specialists and a wider range of expertise.

537. Are we in danger of losing that degree of expertise which is necessary to give proper curation to these important collections we have?

(*Professor Hawksworth*) Absolutely.

538. The people with training are not coming forward?

(*Professor Hawksworth*) That is correct, and there are not the posts for the people to curate the material and provide the identification work.

539. We have been told by other witnesses that curation has at least two different levels, one of which

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is research-dependent, the other of which is not. Can one do better with the work force one has?

(*Professor Hawksworth*) Possibly. It is difficult to say without looking at it in a national context. The point we make in our submission, paragraph 48, is that there is quite a substantial amount of money going into systematics but there is not any cohesive view of this. If you actually add up all the little pots of funding that are going into different institutions, it comes to a fairly appreciable sum, but there is no overall co-ordination and planning of that. If there was an opportunity to rationalise some of the curation, say, for example, if you actually managed all the molluscs at one site, that would perhaps make more sense than deploying three or four curators scattered round the country.

540. That is what is known in your phrase as rationalisation of collections?

(*Professor Hawksworth*) Yes, certainly in their management and so on there could be a lot more cohesion.

541. If they are owned differently, how do you achieve the rationalisation you suggest? Do you set up a board at some point? Who would comprise that board?

(*Professor Hawksworth*) With regard to ownership, I think the ownership could remain with the organisations that have the material. This has already been done with the Royal Botanic Gardens and the Natural History Museum which swapped substantial amounts of material in 1968. All specimens that changed hands are indicated to be on permanent loan. This is stamped on the sheets and so on concerned, so they could be retrieved. I do not see a difficulty with that. Technically things could be on permanent loan. As regards the Board itself, we would see it having on it people who are responsible for funding at the present time. That obviously would include representatives from bodies like the Natural History Museum and Royal Botanic Gardens, Kew, also CAB International, but further the Research Councils, the Scottish Office and the Welsh Office (that fund museums and big collections, including the Royal Botanic Garden, Edinburgh), some of the big provincial museums would need to be represented, particularly Liverpool, and also the universities that have major collections, such as Oxford and Cambridge Botanic Gardens whose living and dried collections are very important. There are some research council institutions, particularly NERC, (bodies like the British Antarctic Survey, Freshwater Biological Association, Marine Biological Association), and also the Medical Research Council which funds a lot of work in systematics concerned with bacteria which tends to sometimes be overlooked. We looked for a group which would have these sorts of representatives on it.

542. Would you see it just as a consultative forum from which people could go away to do their part according to what they had agreed, or would you see it as having some real powers because it had money and, if so, where would the money come from?

(*Professor Hawksworth*) My instinct would certainly be that it would have to have some clout,

and would have to have some new money to actually be able to operate in that way.

543. To come back to Lord Flowers' point about the Treasury, what is the case for the amount of extra money?

(*Professor Hawksworth*) I think the case would be that there was a need for the service to actually undertake systematic work in the United Kingdom to underpin United Kingdom biological science. It is important if we are going to do this work well that we know about organisms outside the United Kingdom as well as organisms inside the United Kingdom. We also need to produce the basic works that mean other activities can actually function. For example, there is a lot of concern about environmental protection and nature conservation—there are not yet the means to identify many of the groups of organisms actually present in the United Kingdom. There are also back-up services that relate to bigger problems requiring identification and advice. I would suggest that the sort of money being talked about is relatively small.

544. You did make an estimate in your paragraph 66, or whatever it was. You estimate current expenditure on research in this field is between £30-40 million and an extra £10-20 million new money is needed. Presumably that was not just plucked out of the air?

(*Professor Hawksworth*) I do not know how much time you want to spend on this now. The £30-40 million was very much a back of an envelope calculation.

545. I do not think it is necessary to go through it here. If you have it on paper perhaps you could submit it to us, and also the estimate of the extra amount of money. That would be extremely helpful.

(*Professor Hawksworth*) That would be easy.

546. We are finding it very difficult to get a handle on exactly how much money is spent in this field, because there are so many different providing sources.

(*Professor Hawksworth*) I think the Committee could probably do a lot better than we could, because we do not have access, of course, to many of the detailed accounts of the different organisations. At least we could identify approximate orders of funding.

547. You cover the whole of the plant and animal kingdom essentially, do you not?

(*Professor Hawksworth*) Yes, this is seen as a collective thing.

548. Could you let us have that?

(*Professor Hawksworth*) Certainly.

549. It is said in the Department of the Environment's evidence that the flora and fauna of this country is probably better known than that of any other country in the world, and yet I noticed in your evidence that you made a remark which appeared to imply that we were far from having anything like a comprehensive inventory of plants and animals in this country. You pointed to the example of Australia in having this bureau. Would you like to enlarge on this. I am slightly perplexed whether we are in a good state or a bad state?

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(Professor Hawksworth) It varies and depends very much on the groups concerned. With groups like the flowering plants obviously things are very well known; there are detailed mapping schemes and so on available. As soon as you start to move into groups like microscopic algae, all of the fungi and many of the insect groups, protozoans, nematodes and so on, while the United Kingdom certainly is better known than many countries we are far from having authoritative works of cataloging what we have got. There are not even checklists of names for many of these groups available at the present time. Australia is tackling this very systematically. I have just come back from the USSR last week and their scientific institutions see as their main priority producing the sorts of catalogues of the flora and fauna that are just not available in the United Kingdom.

550. Do you think that extra information, it could not be "at whatever cost", is economically justified?

(Professor Hawksworth) I think it is justified in terms of if you are actually trying to make decisions about land management and so on. If you are talking about developing a site, if you are going to build a housing estate and factories and change policies about where you site power stations, then the sorts of monies you are talking about are relatively small. You have to take these things in context.

(Professor Greenland) You have to make a disclaimer, at whatever cost.

551. Could one just go along a little from this. One sees a vast amount of data moving up which somehow has to be handled in a systematic way and this brings us to the question of computerisation, which must figure very largely because of your large databases. Can you tell us how you see this developing in this country, and whether any policy should be created for it and whether any resources are needed?

(Professor Greenland) The answer is yes.

552. One speaking does not preclude the other!

(Professor Greenland) I think Dr Harris may also like to comment. Dr Harris is the one person most closely involved with the Museum. Computerisation of taxonomic work is an area of fairly rapid expansion at the moment, but I think we are behind what has been happening in other parts of the world, in handling the various methods for modern taxonomic research. There is scope for quite a lot more to be done. If it is handled on the scale that is commensurate, the entomological part is the most difficult. In the handling of that work and the putting together of the information in an appropriate manner, one is still groping a little bit to find the systems that are needed. There was a project, which Professor Hawksworth can talk more about, for the fungi which the US National Fungus Collection at the Smithsonian in Washington was talking about, which was looking for funding of the order of 3-4 million US dollars over two or three years to start an international database which would have the appropriate systems for entry, but that did not get funded.

553. Did the Smithsonian wish to do it out of its own money or to be funded from other sources?

(Professor Hawksworth) That was USDA. That particular proposal was from the United States Department of Agriculture, and they were trying to get the funding through US AID (US Agency of International Development). One thing that does need to be stressed with collections is that there is a vast amount of information in those collections; in fact I have just written a paper with the Keeper of Entomology at the Natural History Museum about the importance of collections. There are masses of information about distributions, seasonality and so on which are in those collections, which we do not easily have access to. As one becomes concerned with issues like climatic change and so on we have masses of information in the United Kingdom on the distribution of organisms, and this could be related to different climatic and other factors.

554. You make the point in fact that these changes can be used to monitor environmental change?

(Professor Hawksworth) Yes.

555. Does this not all need really an international agreement about the form of the computerisation or, at least, systems in different countries which are compatible?

(Professor Hawksworth) That is right. I think this is partly in hand. Under the International Union of Biological Sciences, there is a thing called the Commission on Taxonomic Databases for Plant Sciences, and they have developed international standards for data exchange and field structures for this kind of information.

Lord Flowers

556. You are building an expert system presumably?

(Professor Hawksworth) No. This is for a relational database from which you can retrieve things. Expert systems, as I understand it, are slightly different animals. You interrogate those and ask questions and they lead you through a path, whereas in relation databases we have central data files which can be used for many different purposes. An expert system is usually tailored for a specific item, like how to identify something, as I understand it.

Earl of Cranbrook

557. Could I ask whether the witnesses are familiar with the biological recording system in the United Kingdom?

(Professor Hawksworth) Very much so, yes. The Biological Records Centre I have had significant contacts with and I worked with Dr Frank Perring there on a project in the 60s. The problem really is that if one is going to do this work seriously it must be done on a much greater level with modern equipment. Some of the big United Kingdom Societies involved in mapping in fact do not now use the Centre's services because they have better computing facilities at universities or elsewhere. At the moment we are not able to, in fact, answer questions. For example, there is quite a lot of concern in Europe at the moment about the effects of acid rain on mycorrhizal fungi and its relationship to trees. There was no mapping system for fungi in Britain until recently when the British Mycological Society

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started one independently. As to the Biological Records Centre, it cannot now answer questions as to whether particular species have actually declined or not in the United Kingdom, not only fungi but the vegetation itself. It would be very nice to be able to answer these questions but, if we had a lot of the records that are in the collections on computers at least we would have a start.

558. This seems to imply dissatisfaction with the way the Biological Record Centre has developed.

(*Professor Hawksworth*) I think it has probably developed very well within the resources it has actually got. I think it is a matter of, if you have very limited resources, obviously what you can do is very restricted. I think the staff there would say they were dissatisfied with it. I do not know.

Lord Walton of Detchant

559. The first point which puzzles me is your Table 1, the known and conservatively estimated number of world species. It is astonishing to find that you estimate that only 10 per cent of bacteria have been recognised and characterised. Then you point out in relation to insects that various estimates have been published ranging from 6 million to 80 million, so that the range of error seems rather large. How are these estimates derived if the organisms have not been recognised and classified? Secondly, one class of organism not mentioned in your table is the viruses both in relation to plants and animals. I wondered where information about those comes from—the NERC Plant Virology Institute might be one source? I would be interested to have your comments on viruses.

(*Professor Hawksworth*) Some of these were taken from another paper I have in press which includes viruses in the Table. The list was a selection of estimates based on different methods, usually from experts in the different fields, and I did not want to clutter up the paper with lots of references. We can provide references for all the figures there, if required. Basically they are based on calculations to do with the extrapolations from what is known already about the extent of host specificity and so on. To take the insect number, there has been a lot of debate about this, but people seem to be settling at around the 6 million figure at the present or perhaps up to 10 million. Some of the larger figures now seem not to be talked about by the specialists in this group. As regards the viruses, the figure comes out at about 3 per cent being known, like the nematodes. I cannot remember the total numbers in all the groups. The bacteria figure is probably an under-estimate, the figure of 30,000 coming from Professor Sneath who was based at the University of Leicester and is now retired. He is in fact trying to do some more accurate calculations based on the lines we used for the fungi. In fact, at the present time with the bacteria and such organisms there are a lot of unculturable ones, which is part of the problem. You can detect things, using molecular probes, where you cannot culture things. The extent of unculturable microorganisms is not known, so the bacterial figure could well be over-estimated at 10 per cent, meaning we may know much less than 10 per cent.

Chairman

560. May I return to the point which you made yourselves in your evidence? You said you had some concern about the research policy at the Natural History Museum and then you went on to suggest that perhaps curation and research should, on the one hand, be separated from the exhibition and educational functions in the two Botanic Gardens and in the Museum. How would you envisage that actually happening? In particular how does that link in with your proposal for a board of systematic biological research?

(*Dr Harris*) So far as entomology is concerned, which is our main involvement in the Museum but there are others, there already is, and has been for the past 20 years or so, substantial separation of the public gallery activities and the work of the scientific departments. Having seen the recent quite harsh pruning in the Department of Entomology, we are really very concerned about the way in which resources for essential and continuing research in entomology have been very rapidly eroded over the last two years. We would argue, I think, that there could well be advantage in having a clearer separation of the funding and the management direction of the research functions as opposed to the so-called front of house public gallery functions. How that can be achieved in entomology is a matter that could not be settled quickly and easily. Essentially in entomology we are faced with a huge open-ended assignment. The figures we talk about—the 6 million species—really are “guesstimates”. We started in entomology in the Museum because there were real needs in providing services for development in tropical countries, and those were human needs—control of pests of medical importance, the mosquitoes, tse-tse flies and so on. There are other substantial needs to which it may or may not be easy to attach values. If I could just quote one example in the last few years, the North American screw-worm had been accidentally introduced into Libya. Because the Natural History Museum maintains collections and experts, it has been possible rapidly to identify that species, to recognise the threat to tropical Africa, to alert international organisations, and there is at the moment an eradication scheme in Libya being run with very substantial US involvement, which is rather surprising, in applying the male sterile techniques to the eradication of this major pest. That, I think, is a very tangible benefit of maintaining the basic scientific structure in the Museum. But the problem obviously is a very critical one of funding now, which did not exist in the past. It does exist now. We have expressed our concern. My personal concern is that I myself have seen an excellent international department of entomology literally decimated in a year.

561. Can you give some idea of the scale of that in terms of staff losses?

(*Dr Harris*) It was a literal decimation—14 staff lost out of a department of about 80. Those positions are lost. That expertise is lost. We are on the very slippery slope there. The big question to me is, how can the decline be stopped and reversed? The way that I see forward is not so much talking about the needs of United Kingdom taxonomy but really

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talking of the United Kingdom's international role (which is there for historic reasons which we have indicated) and it is a continuing need which we are servicing, we continue to service, in conjunction with the Museum. But the question for ourselves, and also for the Museum, is how can such relevant work be funded in the future?

562. Since 1987 you have had access to Research Councils, have you not, for funding research?

(Dr Harris) We as an Institute have not. We have benefited comparatively little from external funding for what we have been doing.

563. It is true that you can apply, is it not?

(Dr Harris) We can apply. We are all the time. We are looking for external funding to support work that we wish to be involved in. Our main success has really been from ODA funding.

Was that a policy decision of the trustees to reduce the size of entomology from 80 to 66?

(Dr Harris) That was a policy decision of management with the support of the Trustees, yes.

564. That is not the whole of the Entomology Department, I imagine?

(Dr Harris) It is not the whole of the Museum. The loss of posts is 100 overall.

565. Of the staff?

(Dr Harris) Across the Museum, which is a very substantial erosion.

566. What was the staff before the loss of the 100, the comparable status?

(Dr Harris) I do not know, I do not have the figures because that would relate to the whole of the staffing of the whole Museum. My main concern, as I say, is about the literal decimation of the entomology department.

(Professor Greenland) Could I add one point about the international relations of the work. Dr Harris mentioned the North American screw-worm in Libya, but I think it is one example not of the benefits for Libya and Africa but also of the importance of this work to the United Kingdom, because of the threat of species outside the United Kingdom which might enter the United Kingdom. The European Plant Protection Organisation has recently commissioned CAB International, on behalf of the European Community, to prepare quarantine sheets for some 200 species of which about 60 are a potential threat to Europe from outside. Some of these are within certain parts of Europe, but we are not isolated. The movement of material these days means that the quarantine problems are very considerable, and one needs to be very up to date and very aware of what is happening outside the United Kingdom if we are to protect ourselves within the United Kingdom. Blue ear disease on pigs is one example of that at the moment.

Earl of Selborne

567. Could we just follow up the specific requirements of agriculture in this country, and you have made the point about the blue ear disease on pigs. Are you aware if there is a national policy, presumably within the Ministry of Agriculture, that exists at all for the maintenance of collections of

plants, pests and diseases which have a crop value in this country?

(Professor Greenland) Essentially for the Ministry we have provided that service for many years.

568. If a gap is identified, as it might be, where would you be looking for the collections which would be required?

(Professor Greenland) If it is not a virus disease then certainly with plant pathogenic bacteria or fungi you can go to the Mycological Institute.

(Professor Hawksworth) There is the Public Health Laboratory in Colindale for human pathogenic bacteria.

569. It is really important that the two organisations, Colindale and yourselves, do match. Is there in any sense a complementary role here?

(Professor Hawksworth) Yes, there certainly are complementary roles. The reason why we suggested that the management of the systematic work for the big institutions might be separated is that there is not any rationalisation between them. Each institution makes its own decisions. There is an agreement called the Morton Agreement between the Museum and the Royal Botanic Gardens, Kew with regard to botanical collections for example. This did not, in fact, stop the Museum deciding it was going to stop having scientists that were doing research in some of the areas covered by the Morton Agreement. A unilateral decision by the Museum means a loss of capability in the United Kingdom in some groups which are important to people who want some expertise to name things, and this is the worry. Unless you have a group which is active and can oversee this and have some say in how funds are directed, you do not develop this sort of national plan. Much of what we do have, particularly on the culture collection side, for example, in relation to bacteria and also concerning fungi and yeasts, has really developed historically without any sort of overview; policies change, collections are suddenly endangered, and nobody quite knows what to do with them.

570. It seems rather ambitious, does it not, to try and get towards a global biosystematics network if we have not achieved it on a national basis?

(Professor Hawksworth) The global aspects that our organisation has been concerned about are global aspects relating to the groups that we deal with. My own Institute, for example, has close ties with a number of mycological centres around the world that we work very closely with indeed in exchanging specimens, cultures and discussing what the staff do and so on. It is really trying to firm up some of these things particularly from the point of view of developing new centres in developing countries. We were thinking of subject-orientated networks rather than something to cover everything. For example, with flowering plants, some progress towards this has been made through the Royal Botanic Gardens with their Species Plantarum Project. They are getting specialists around the world from different centres to actually provide regional inputs to world checklists of particular groups. Some of this is going on but it does not really have the backing and management at an administrative level,

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but is done very much between organisations and the scientists involved.

Chairman

571. One final point which we have not touched on and I am still a little confused about—you referred with some pleasure to the location of activity at near the Royal Holloway and Bedford New College campus, but in your evidence, towards the end of it, you show a degree of scepticism about leaving biological research within the universities. I was rather puzzled by what appears to be a contradiction.

(*Professor Hawksworth*) What we felt should not be left in the universities was the long-term maintenance of collections and the long-term revisionary works. Where I see a great strength in universities is, in fact, in new techniques being developed. For example, in the molecular work. Rather than develop your own molecular unit, why not do it in association with a university that has a huge molecular biology laboratory and a big biochemistry department and a proper chemistry department, and there is a lot of expertise besides. If you are actually looking for short-term research projects, or requiring a new technique that is ideal work for universities, there is no question about that. Similarly on the ultrastructural side, where they have got excellent equipment, or major computing equipment which one would not normally expect to compete with. It is the long-term curation of collections, living collections and dried collections, long-term research on systematics where it may take 50 years to produce a series of floras on the region, that are difficult to cope with in a university system.

572. Would you go further than that and say, for example, whole departments of entomologists' collections should be moved to the Natural History Museum?

(*Professor Hawksworth*) Not necessarily. It is a matter of rationalising where the expertise should be. I think different places would move in different directions. If you had an overall management there would be potential if it was felt desirable to actually move a lot of the collections that were in a particular group to where the specialists were, for example. This is not happening at the moment. You will end up with institutions curating material which they have nobody doing research on, that cannot provide identification services from, and so on, and probably cannot even curate them to the standards necessary to answer enquiries that come in.

573. Thank you all very much. Is there any particular point we have not touched on that you feel should be brought to our attention which is not within your written submission either?

(*Professor Greenland*) Could I just pick up the last point about the global network and what one is trying to do there, and I think it relates to Lord Flowers' point earlier of the devolution of the funding. Because the Natural History Museum's collection has existed within the United Kingdom, and others in our own institution as well as elsewhere, much less has been done elsewhere in the world than might have been done. What we hope to do is to try and stimulate the organisation of a number of regional centres around the world, which would take the onus away from us and put it within countries in the different regions. That will take time, of course, but if one is to have a secure basis for all biological work I think one needs to do this.

Chairman] Perhaps appropriately you are wanting to use the word evolution of organisations as well as organisms. Thank you very much.

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Examination of witnesses

DR DAVID FISK, Chief Scientist, and DR P J W SAUNDERS, Chief Scientist Group, Department of the Environment, called in and examined.

Chairman

574. Good morning. Thank you very much for coming. You have heard part of what has gone before and know what is involved, but I do not think you were there at the beginning so I will repeat my question. Thank you very much for your paper, do you wish to emphasise a particular point in it or draw new points to our attention in an opening statement or go straight into questioning?

(*Dr Fisk*) Thank you, my Lord Chairman. I think there are just two points I would like to make in opening remarks which I think underlie a points in our evidence to you. As you will gather from our evidence, DoE formally makes very little direct—I emphasise “direct”—use of systematic biology skills. Those skills are used widely by those to whom we contract research work and they are used widely by our external advisors such as the natural countryside

bodies. I might add; since it is not actually referred to in our written evidence, that a rather small—but no doubt important in its own right—national collection of wood destroying fungi is held by our research agency, the Building Research Establishment. Once again as an agency they represent one of the advisers to the Department rather than the Department itself. I think perhaps that puts us in some contrast with a number of other major government departments who have activities in this area. Since the Committee is likely to be taking evidence from many of those bodies with whom we contract work or take advice directly from, I hope you will forgive me if I say it is probably not appropriate for my Department to report secondhand the hearsay we get from them. We will try to be as disciplined as we can. However, I would not want our written evidence to be taken to imply that we had a sense of complacency about matters. This applies particularly to the new area of concern

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[Continued]

[Chairman contd.]

relating to the loss of global biodiversity which was discussed last year by Mr Patten when he was Secretary of State in his NERC lecture. The seminar of scientists mentioned in that lecture, which he proposed to call in order to look at priorities, is in fact to take place at the Natural History Museum on Thursday and continue on till Friday. It will review, we hope, what British science can contribute and I shall be pleased to let the Committee have a copy of the report of the meeting as soon as it is ready. Clearly it will be quite important to your deliberations. The second point I would like to say is perhaps just a little bit of semantics, but this seems a topic suitably appropriate to be semantically accurate. I would like to differentiate from the outset between systematic biology as a body of scientific knowledge and systematic biology as a research activity that adds to that body of knowledge. As a user of expert advice, we are very conscious that a field of research may be exhausted when, for example, a family of pests has been fully identified but that body of knowledge may continue to be of active use by practitioners thereafter. I make that point only because the Committee's enquiry addresses itself specifically to systematic biology research. Clearly the knowledge in this particular case is of very great importance itself.

575. We fastened on what was then Mr Patten's lecture, which I also heard, on biodiversity, and I think we all of us feel that that is on the evidence a very important aspect of the case for maintaining a high degree of competence in this country. What I think we do find ourselves in difficulty in trying to discover is exactly what the level is and who pays for it. Have you any observations, even from your one stage removed by your own admission, on the position in this matter because you must be also aware, I take it, of this general and rather widespread concern about the state of systematic biology research in countries.

(Dr Fisk) I guess, my Lord Chairman, you will probably press us a little on that question. Rather than take it as "When will you stop beating your wife?", I will take the first one first, if I may. The context of Mr Patten's lecture was, of course, that the United Kingdom was one of the first nations to call for an international convention on biodiversity. Biodiversity is, after all, a sovereign resource of the nations concerned, and one must not slip into the habit of assuming that other people's resources are in some sense our own. The United Kingdom has a very good reputation in conservation. Much of our skill is systematic biology relates to our need within bodies such as the national countryside agencies to support that programme. But very clearly there is great concern in other areas of the world in which that biodiversity infrastructure does not exist. This Committee has taken evidence from the Overseas Development Agency and will understand that there has been a long tradition in United Kingdom aid of relating the natural resources to the form of aid that is given. Indeed, the ODA are major users of some of the United Kingdom resources in this area. The Convention itself is in its rather early stages in terms of its negotiation of what are the issues of technical transfer, aid and assistance for those who wish to

make greater efforts to maintain their own biodiversity but who do not have themselves the resources to do it. In a sense that is where the story starts. Mr Patten's lecture gave an estimate that British spending in biodiversity in research was about £15 million with perhaps another £10 million associated with aid projects—that is about £25 million minimum. I think it is too early to judge whether in absolute terms that figure is right or wrong, but clearly one of the purposes of the seminar is to assess, as indeed Mr Patten indicated, whether we have the priorities right within the umbrella of funding.

576. Is your own view that we do have an adequate base here from your stance—and, in view of the fact that when the Natural History Museum announced its policy that produced, as I am sure you must be aware, a great wave of protest from all over the world which seemed to think what it was doing was wrong, it is difficult for you to make a judgement on this—and was that just the response of an embattled scientific community to change, or was it an expression of some real concern that we had responsibilities which we were somehow not meeting?

(Dr Fisk) My Lord Chairman, I do find that a difficult question to answer in terms of formal evidence. Our own estimate in DoE is that our direct involvement on which I can draw evidence is perhaps only £0.5 million per annum in systematic biology and, therefore, in some sense we would not be the major department to bring forward evidence to you. On that basis, and, if I were honest, that part of our programme that uses systematic biology techniques at the moment has not shown signs of stress, but at that scale of that programme, I would counsel the Committee that what you would not expect to see signs at this stage. You would indeed look to my colleagues in MAFF and ODA to give you a stronger steer. I did consider, since I rather anticipated this question because it is one the Committee has asked a number of other witnesses, how best I might have helped and in return I can only offer an alternative anecdotal observation. There is clearly a more global question as to whether the overall balance between the new calls on the life sciences in general and other calls on science are correct. I struck upon this actually a few weeks ago by reading in Science which I of course always trust, that the NSF in the United States had a budget of \$13 million to spend on both classical and molecular biology. On my computation that is five days of the expenditure on the development stage of the space station that was agreed in the Senate Appropriations Committee yesterday. It seems to me perhaps some of the stress and strain you are observing is part of the tension of trying to get the balance within the total science budget correct and that, indeed, one has to be cautious, about inward fighting, if I might put it that way, in life sciences. The issue you raised originally is concerned with biodiversity, not just systematics; it is concerned with major issues of biodiversity, major issues in earth observations. All those are major strains on the balance of the total science budget. There are two questions. Is it impertinent for me to suggest that the Committee might look at them in

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[Continued]

[Chairman contd.]

that respect? There are two questions, one of which is the balance within the life sciences expenditure, and whether that is correct, and the second whether some of the reasons why systematic biology has been argued as so important are not actually part of a co-operative argument on the whole overall balance of life science with natural research activity?

Lord Flowers

577. It is not my impression, but maybe I have got it wrong, if a lot more money were made available to biology in this country that much of it would go to systematic biology, I have the impression that it would not.

(*Dr Fisk*) My Lord Chairman, that, if you like, was part of the thrust of my point. There seem to be two questions on this issue of the scale of resources, one of which is whether in the development of biological research overall, the systematic biology base is increasing at a rate which reflects the rest of the biology base. The extent to which some of the issues have been put before you is important for systematic biology, and not part of a general argument for a larger portion of life sciences. To take Lord Flowers' point, it would certainly be true that in other issues of allocation of research priorities, the archiving of data, whether it is fossil or live or collections, has not always itself had a priority within the Research Councils' own basis. Some of the issues I know the Committee have been wrestling with, which are not only how to fund research but how to fund the maintaining of the basic collections, are actually problems which are parallel in keeping and maintaining geological samples, records, archives, maps and so on. I think Lord Flowers has a good deal of thrust in his observation, if the overall funding is extended, as to the extent to which this would be reflected in a proportional increase in systematic biology. The other point I would make, which reflects partly the shift in balance in our own programme, small as it is, is that there is a second tension within the systematic biology which has taken on board the new and really quite expensive techniques of the molecular approach. It would be true to say that in the US and Germany there are very similar tensions between classical and molecular, which are partly funding tensions, which also put a great deal of strain on the type of activity the Committee has been investigating.

Chairman

578. I am sure you are right in the sense that our problem is, in fact, partly concerned with getting a balance between newer methods and what is still essential, namely, the older methods. There is a feeling that in a period of tight funding the glamour of the former tends to exclude some of the latter. What we are looking for is that which is the product of the interaction of these two, which gives the best value for money invested. That is the difficulty. When is a system in such a state that it needs external direction applied to it? Do you feel that is a correct analysis and that perhaps we are at a point where there should be some correction applied which might involve enhancing the linkages between the two sides which should be working together?

(*Dr Fisk*) Your summary is a rather skilful summary of my point. That is certainly the direction I had in mind.

579. Plagiarism is always the best kind of flattery!

(*Dr Fisk*) Certainly looking, I must confess, at our very small programme, that is exactly the thrust of where we are going. One of the areas in which my Department has a direct use of systematic biology techniques is that it is the national authority for implementing the convention on trade in endangered species. That occasionally requires us to use systematic techniques in order to establish, if nothing else, the substance of the case. You will see from our research programme that has very gradually shifted from using classical approaches, which are actually the concept of the convention itself, to using molecular approaches as a way of getting much closer to the issue. As far as the DoE is concerned as a user of this data, that transfer was very smooth. It was not an internal revolution, but simply looking at the best solution to the problems that were materialising. The Committee will have recognised that the problems to which systematic biology is now being addressed are actually different from the problems addressed 20 years ago. To be a little facetious, at one time we were looking for better breadfruit plants to feed slaves in the plantations; we are now clearly looking at a very different argument on the use of pharmaceuticals and molecular structures, which still requires a basic set of collections and the understanding of systematic approaches but is addressing a different set of problems. In DoE I think the transfer has been relatively smooth in terms of our customer requirement, in terms of trying to look for the best technique. We do not feel that we have abandoned classical techniques but simply feel we have some problems which are being better handled.

Lord Flowers

580. May I ask Dr Fisk whether the Department of the Environment has discussions with the Research Councils about the perceptions of changing need for systematic biology?

(*Dr Fisk*) The Department of the Environment is a formal member of the Natural Environment Research Council, so that there is a sense in which we are able to provide an input into the Council's deliberations at a strategic level.

581. They do not do it all?

(*Dr Fisk*) No.

582. That is why I said Research Councils in the plural.

(*Dr Fisk*) Thank you very much. We are also an assessor on the Science and Engineering Research Council. We do, of course, have formal bilaterals with the heads of all Research Councils during the course of the year. At the contracting level our change in emphasis is evident, in the way in which we publish our proposals for research. The reason why I am, as it were, being a little coy is simply to recognise that, within the scale of our programme (and our total programme is about £80 million) the part we are talking about and the change in emphasis, is about £50,000, I guess, is actually becoming rather small

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[Continued]

[Lord Flowers contd.]

compared with similar changes in view which must be occurring in the orientation of, for example, the MAFF programme which is addressing not dissimilar issues but on a much larger scale. There is a sense in which I would have expected others to recognise what is a fairly common trend who are actually much larger users of this direct resource.

Earl of Cranbrook

583. I take Dr Fisk's point, my Lord Chairman, that new approaches and new developments in systematics still need collections as their base, but those collections they need are increasingly of a new type. What they tend to do is leave behind, as a wash on the shoreline of history almost, the collections that were made in the past for other purposes. In ornithology, for instance, the new taxonomy may be based on biochemical techniques, yet the vast store that requires still to be kept and curated will be of dried skins and perhaps alcoholic specimens. How do we deal with the responsibilities for maintaining these collections which relate to techniques which are perhaps now really only of historic interest?

(Dr Fisk) In a sense I believe, my Lord Chairman, this is a question we would very much hope the seminar in the next two days is going to address, because the role of United Kingdom research in this area is particularly difficult for the United Kingdom to assess. As Lord Cranbrook has mentioned, our collections in many respects are not simply a collection of systematic biology but are also a collection of history and reflect trading patterns, commercial interests and particular bilateral relations extending over very many years, and in that respect they are unique. At the same time, to my mind, that is not necessarily a sound base for deciding where you are going to go next, because the very problems you refer to on funding, and internal priorities even within the science base, suggest that you need to identify what is likely to be the next sound foundation for systematic biology and you look for a useful bridge. I fear I have replied in a generality to a specific question, but that is simply not to pre-empt the discussion that the Department is hosting in the next two days.

584. Systematics, my Lord Chairman, does have these tremendous roots in history; the history and development of nomenclature is tied inevitably with systematics. It is a very long tale; it may be a burdensome tale but it does have to be carried forward.

(Dr Fisk) I thought that was largely a restatement of the original question, which is a point I take as fact. The challenge is that, clearly, if the collections are to become only historical clutter I fear that the resource problems the Committee have identified will actually continue to exacerbate.

Chairman

585. You are quite explicit at one point in your written evidence by saying that targeting is absolutely essential in the research which is done. I think this was with special reference to overseas work, if I remember. I was not quite sure from your

paper what that meant. Would you like to enlarge on it, and how it would be done and who would decide?

(Dr Fisk) First the Committee may know that ODA very recently—I think within a matter of a week or so—have produced their own thinking in the form of a booklet which I think they have probably already sent to the Committee. That is very much the approach that my Department would wish to commend to the Committee. It looks for causes and reasons, it tries to use these as ways of targeting the priority areas, in ODA's case addressing aid for third countries' priorities. It is an important way of tackling the problem. The difficulty we perceive is shared by many. If we took an upper estimate of 50 million species, even if every member of the United Kingdom from the age of 1 and above was a taxonomist, we are not going to make a great deal of progress in understanding the relationship and distance between species; whatever approach we have will require some prioritisation, even if we had the full resources. We want a strategy, an actual, natural prioritisation, so in some terms targeting is a statement of the obvious. Clearly some of the priorities do not come from, for example, departments like my own; they come from the international scientific fora who are taking priorities within curiosity-based research. Others, of course, relate to activities like the international conventions which will try and establish the quite different priorities between the developed and developing world as to how decisions on this should be taken forward. We were simply signalling that, if one took what might have been a plausible position and simply said we were just categorising where we are now, we would never finish that. We need a strategy.

586. It does seem, does it not, given that what we are talking about how each year one has to start with international agreements parcelling out, as it were, work to a considerable degree before one can begin to have priorities within any nation's own individual programmes, that that is what is implied by your proposal.

(Dr Fisk) I do not think in the developed world the requirement for an international consensus is in any way a precursor of the ability to carry on with one's own conservation programmes. The more crucial issue is the great loss of biological diversity in those areas of the world which already have very high diversity but at the same time are under enormous development pressure. That is a rather special part of the entire package of collections and systematic biology. That is clearly an area which needs prioritising, both in the collection and in the assessment of the species systems and strategies. That is the nature of the present inter-national debate and discussion. The United Kingdom, my Department and the DTI together, have funded a special study concerned specifically with the issues of technical transfer which relate to the Biodiversity Convention. That will help some of the priorities because technical transfer includes abilities and access to collections, skills in systematic biology and, of course, conservation.

587. Has that work which has been done been published?

(Dr Fisk) It is work which has only just begun.

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[Continued]

[Chairman contd.]

588. It will probably not be ready by the time we need to report. Is there any information you can give us which would be helpful to our work?

(Dr Fisk) May I return in writing? We may be able to give the Committee a little more detail on that which may be helpful.

(Dr Saunders) It is a relatively short-term consultancy project—about three months. We will check that for you.

Chairman] Thank you very much, Dr Fisk and Dr Saunders. That has been extremely helpful and valuable to us.

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Examination of witness

DR PETER BRIDGEWATER, Director of the Australian National parks and Wildlife Service, called in and examined.

Chairman

589. Dr Bridgewater, it is extremely kind of you to interrupt your schedule to meet us here. We know you are just in passage, as it were, are you not?

(Dr Bridgewater) I think, Lord Chairman, that is probably correct. I have just spent two rather hectic weeks in Iceland at the International Whaling Commission and a further meeting with IUCN in London at the end of this week. So this timing was quite fortuitous.

590. It is very helpful to us. We are extremely grateful to you for your interesting and direct remarks, if I can put it that way.

A. Yes, now I read it in cold blood, having dictated it before I left, they are somewhat direct, but I feel it is probably also a fair reflection and certainly, listening to some of the comments from other witnesses this morning, I think they perhaps put a sharper or different cast on some of the comments.

591. Would you like to do that at the outset and say what points you would like to gloss in whatever way you like before we come to questions?

A. Perhaps it would be useful just to sketch precisely what my role is and my organisation's role is.

592. When you do that, would you also, since you are obviously English in origin and know the scene over here, answer the question not answered by the previous witness, namely, whether we need that kind of bureau in this country?

A. I think the answer almost certainly is yes. But I will come to that directly. Although my organisation is called the Australian National Parks and Wildlife Service, that is somewhat a misnomer because it gives the impression of rangers and 4-wheel drive vehicles and very little else. In fact, we as the National Parks Service both are a user of systematic biology and also have in our service an organisation called the Australian Biological Resources Study, which was established in 1973. It had a slow and rather jerky start because it was established by the incoming Labour Government in 1973 which produced a lot of reforms in a wide range of areas. That Government did not last very many years and by the time ABRS was just about to start developing the government changed and subsequently there was a period of slowness in development. That takes us to about 1980 when the alternative government had become

equally convinced of the necessity for biological resources study and reasonable funding began, I suppose, in earnest. So the decade from 1980 to 1990 saw a slow growth in real terms against the original amount which in 1980 terms in Australian dollars was 800,000 per annum. I cannot even do the conversion to Australian dollars today, let alone to pounds sterling, I am afraid. As to the initiatives from biodiversity, which I was intrigued to hear mentioned many times this morning, I must say I have a somewhat cautious view of the use of biodiversity. Certainly the Biodiversity Convention it seems to me is a very important convention, but it is not so much focused upon systematic biology as some might have us believe, and I am not sure it will be the vehicle which will actually carry it forward internationally—it may, but I have a somewhat jaundiced view on that. The issue of biodiversity arose in Australia and became almost a political catch-cry about three years ago. As a consequence of that and pressure from non-government organisations, the Government has made two fairly significant increases in funding for the Biological Resources Study, one of an additional A\$1 million a year in this last Australian financial year, and in the new financial year which begins on 1 July and additional 0.5 million. That is bringing us to A\$2.5m a year for essentially systematic research. There is still some systematic research funded through the Australian research scheme, but that really amounts to little more than A\$100,000 and is primarily directed towards new approaches in systematic research.

593. That comes through the ARC?

A. The ABRS grants are run very similarly to the ARC, that is they are peer assessed, but the pool originally was designed to cover all systematic biology from theoretically bacteria viruses right up to higher plants and vertebrates. It very rapidly became obvious that the pool of money that was available was far too small to actually satisfy that need, and so we hit upon a scheme of what was called "preferred objectives", which I alluded to in my letter, where we specified certain groups on a rolling 3-5 year programme. That meant we were able to set priorities as an advisory committee saw them and essentially change them at regular intervals so that we did not just do work on solely one particular group of higher plants, or solely one set of mammals and birds or ants. There was a particular focus in terms of

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[Continued]

[Chairman contd.]

Australian insects, and there were a great number of other areas of insects that were not being done. That, I think, has actually been extremely successful. The idea of having one national focus for systematic biological support, which draws together the communities in state museums and herbaria as well as also the commonwealth institutions.

594. And the universities too?

A. The universities as well; but like this country, and indeed it seems to me most countries, universities have almost opted out of systematic biology *in toto*. This actually does cause a particular problem, because there has been in recent years considerable pressure for even more money to be put into this area by the government. Frankly, I believe that the amount of money we have available at the moment is being able to be wisely spent. I suspect that it would be difficult for us to spend much more money wisely, because we are at the moment utilising *in toto* the taxonomic resources of Australia virtually to their fullness. We do, however, also support other researches in other countries, particularly the United Kingdom. We have supported workers in Kew, for example, and we have supported workers at the Natural History Museum. We also have a scheme, which I did not mention in my letter but which may be of interest, which is the botanic liaison officer scheme where, on an annual basis, an Australian taxonomist spends a year in residence at Kew, essentially being the Australian point of contact and answering all the Australian enquiries from Australia on herbaria as well as providing an Australian focus for activities at Kew and, incidentally, acquiring quite a bit of training and knowledge which you can only acquire by living and working around a marvellous institution like Kew. That is probably all I would like to say by way of opening.

595. That brings us firmly back to the United Kingdom. I think at one point in your evidence you raise the question which is that we do have these splendid collections, you do think the level of support is adequate but you do suggest that perhaps if we do not maintain that level of support at a proper level the question would arise as to the restitution of the scientific property to the country from which it comes. When do you think that point would arise, and which would be the countries most affected if we were to continue as we are doing, or would you now want to soften that comment a little?

A. I think I prefer to describe them as slightly impish comments. They are, however, a true reflection of comments that I have heard directors and curators in museums and herbaria make, particularly in museums rather than herbaria because the botanical liaison officer link with Kew has cemented relationships since the 1930s when that scheme began in a way which, with the lack of similar facility with the Natural History Museum, has not been possible. To try and answer your question directly, the point at which there would be a chorus demanding return (and it is the type of specimens that are the critical ones) I really do not know. I imagine if the collections were perceived as becoming rundown, and certainly perceived as becoming inaccessible in terms of being dispatched and returned, and certainly if they were perceived to be inaccessible in terms of

visiting scientists coming to make extensive use of them, then I think you would find an increasing note of discord. It would not just be from our own country. I am sure most of the countries in the Commonwealth, and indeed other countries who have specimens here, would find that their progress would be difficult. In order to progress systematics in a modern way we have to have access to particularly those types of specimen. There are also other things that can only be done in institutions where there are wide collections. One interesting example which the current botanic liaison officer was relating to me the other day concerned a new genus entirely which he had discovered just before he left Northern Australia to take up a post here. If he had had access solely to the Australian collections it would have been quite a puzzling time and quite a long time because he actually managed to work out that it was, in fact, a genus new to Australia, and one which had a very puzzling and peculiar distribution I might add. By being at Kew where collections from all the known localities are actually located, he had been able to identify it correctly and, with one of the Kew taxonomists, even realise that some revisionary work needed to be done now that they have identified this.

Lord Flowers

596. Is that an isolated example or are there many examples?

A. No, it is not an isolated example, I am sure. It just happens to be one that I came across last week by visiting our botanical liaison officer there. There are equal numbers of anecdotes almost every year that come up from that.

597. If these great collections were to be split up and nationalised scientific damage would be done?

A. I believe so, yes. There is no doubt that the value-added internationally of having the collections, which might irritate some in terms of having the type of specimens in the United Kingdom, is enormous. In other words, the Australian collections next to collections from Java, Malaysia and India enable one to make those leaps where there are in fact either disjunct distributions or peculiar family relationships or generic relationships which would not be obvious if you were confined solely to looking at a national collection. It would, in my view, make some of the detective and biogeographic related taxonomic work much more difficult.

Lord Adrian

598. You would not describe the historical collections of specimens and so on as historical clutter?

A. No, I would not describe them as that, but I do have great sympathy with the point raised earlier by Lord Flowers about the Treasury's view on this. It is a view which we have internally in Australia at the moment regarding collections which the Commonwealth has and maintains over and above collections which are maintained by the states.

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[Continued]

Chairman

599. You mean the Commonwealth of Australia?

A. Yes, Australian collections which are maintained nationally in Canberra as opposed to those which are maintained in the states. Our peculiar federal system has all sorts of jealousies and tensions within it which makes it interesting in Australia but also makes it irritating.

Lord Flowers] It sounds just like the University of London!

Chairman

600. What you have said does raise a very important argument for us, namely, the sum of the parts is greater than the whole if they are altogether in the one location. That does seem to argue that whatever one does one should not disperse them, and that brings one on to the point that the host country that has them has to provide, from whatever sources including those perhaps from overseas, the resources to maintain that knowledge base so that it remains useful?

A. I think that is absolutely correct. It would, I believe, be an enormous tragedy if the collections had to be split up because the curatorial efforts were not sufficient, but I think one has to distinguish between curatorial effort, research effort and end use. They are three different compartments. One, in my view, can choose to spend money in all three or any two or even any one, and the critical thing for all the recipients, in other words, the global taxonomic community—and indeed the global biological community—is to ensure that the collections are curated. That is, if you like, the minimum level of input that is necessary. Whether or not research is done in the United Kingdom by United Kingdom paid scientists on those properly curated collections is a separate exercise which can be argued. It could be argued that, in fact, the United Kingdom does not need to carry out research on that, in fact it should charge Australians or Canadians or Indians to come and do work on those collections.

601. Some people have told us you cannot curate collections properly without a certain amount of research, is that not true?

A. Well, I am sure those who say that hold those views strongly. I am not myself personally convinced that that is the case. Taxonomists will almost always maintain that you have to have someone to do research in order to maintain the collections properly. That is not true in my view. It certainly helps and makes for a live institution—certainly the picture I described of just collections being properly curated would make for a rather non-vibrant community, but that would only be the case if foreign scientists did not continue to come and work along with what I am sure would always be a minimal level of input from the United Kingdom.

602. Would you, having heard the evidence given by someone about entomology in the Natural History Museum, find the reduction in staff from 18 to 4 tolerable?

A. I really think, my Lord Chairman, that is very difficult for me to comment on. It probably is not tolerable in terms of going from what was a previous high to what is now perceived to be a low. But, not being in possession of all the facts, I think I am not

really able to give an opinion. If the end result of that reduction is a reduction in the quality of curation of the collection, then I would be concerned. If all that has happened is that the collection is still being adequately curated, but there is still not a high level of research on a wide range of groups, I think I would say that is at least ambiguous.

Lord Walton of Detchant] One question struck me in listening to you: it seems the Australian Government has made a positive decision to put more money into this particular field of activity. We learn from reports in the scientific press that they made the same decision in relation to some other aspects of scientific and medical research, yet your country is not without its own economic problems. Can you explain how this bucking the trend, which is an international one, of cutting money for scientific research in many developing countries, has come about in Australia?

Chairman

603. Could I put another question at the same time? I would say the view just expressed by Lord Walton has not been expressed to me by any Australian scientists.

A. I was just going to say that. My Lord, to answer your question briefly, if you look at it in the scientific field as a whole, the Australian spending on science has actually contracted, though possibly not as much as it has in some countries, especially perhaps the United Kingdom. However, it is not a uniform trend and there have been areas of expansion, including the one that I have just described. It has been driven home, I believe, in the current Government that environmental issues are particularly important and, whether you view that simply in terms of end political advantage or you view it as a more global concern, that is nevertheless the reality; and environmental funding for environmental research in general, whether on global change, biodiversity, land use initiatives, has had significant injections of funding in recent years, and there seems to be at the moment no sign of change. My only caveat to that is that I have not yet seen the budget for this year which I will see when I get back.

604. Coming back to the Natural History Museum to lead you to the point you made in your letter and perhaps did not mean it to have the force it has had, you say, "I am aware of the changes under way at the Natural History Museum, and I am personally sympathetic to some of the reported changes. I would have to say however that they appear to have been implemented in a quite disastrous way" What did you mean by that?

A. I think what I meant, my Lord Chairman, was that if some of the changes that I understand have come about are to try and bring the museum more alive to the general public, I believe that to be a highly laudable aim and one which is deserving of support. If that has to come about by reallocation of funding then so be it, but my concern was that what seems to have happened is, instead of trying to sell that in an effective way, it seems to have almost been the reverse. Certainly the press reports and the scientific journal reports that reach Australia show only the bad side of what is happening and none of the good side, which I believe is also happening. That is really

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[Chairman contd.]

the reason for those comments. I feel that the management of the Museum have not really got the gains to match the losses which were inevitably there in changing the financial mix, which is what I understand they have done.

605. This is because you feel the tactics of the handling of people is not right, you feel, rather than the general underlying purpose?

A. Yes, that is probably a good summary of it. It is always very difficult to handle a group of scientists who are particularly individualistic in their approach, which most taxonomists tend to be. A lot more sensitivity might have been brought to bear. It is not really for me to pass judgment on that. That is certainly how, from 12,000 miles away, the picture emerges. There is quite a lot of concern among fellow taxonomists in Australia who have had and still have many colleagues in taxonomic institutions in Britain, and the telephone and the fax machine buzz with gossip, and sometimes it is well informed but often it is not as well informed as it might be.

606. You have heard evidence given to us here and probably know that we are generally concerned about the lack of closeness of what I call the genetic material end with the straight classification end, and our feeling that these should be brought closer together and information should be collated by modern computerised techniques. Is that the general feeling that you have amongst the community of systematists in Australia? Is it worldwide? Are we in any way particularly deficient?

A. My Lord Chairman, I think it certainly is one of the keys, and it is one of the things we have tried to do in the last ten years, which is to marry as much of the value that new technology can bring to taxonomic approaches as we can. Besides the straight research effort that goes into the ABRS there is a further sum of money which is provided each year for publications, and we are producing three key publications: one is called *Flora of Australia*, which is exactly what it says. Bentham created the first, but it is a slightly more up to date and, hopefully, a more encompassing flora. We are also producing *Fauna of Australia* which is designed to be an English language version of the French *traite de zoologique*, but based primarily on the Australian material. That is a more descriptive natural history-type book. The third is a series of books entitled *Zoological Catalogue of Australia*, and although they are being published as books the information which goes into them is also being processed through computers and is held on computers so that it can be updated. It can be changed very quickly; and my hope, frankly, is that we will stop producing it in book form because I think it is a waste, and it will be solely available either as an online database or as a hard disk CD, whatever.

607. Are there any other questions? Thank you very much indeed, Dr Bridgewater. May I express our appreciation again of your giving up your time.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 18 June 1991

THE NATURAL HISTORY MUSEUM

Mr N R Chalmers, Mr J Peake and Mr J Legg

Ordered by The House of Lords to be printed 15th November 1990

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18 June 1991]

[Continued

TUESDAY 18 JUNE 1991

Present:

Adrian, L.
Cranbrook, E.
Dainton, L. (Chairman)
Flowers, L.

Nicol, B.
Porter of Luddenham, L.
Selborne, L.
Whaddon, L.

Memorandum by the Natural History Museum printed by HMSO, HL Paper 41, ISBN 010 404191 9

Examination of Witnesses

DR NEIL R CHALMERS, Director, MR J PEAKE, Associate Director (Science), MR J LEGG, Secretary, Natural History Museum, called in and examined.

Chairman

608. Dr Chalmers, Mr Peake and Mr Legg, thank you very much for coming along and thank you, too, for the very explicit answers to the list of questions which were sent to you. You also have, I think, some idea of the questions we are likely to put to you. There will, of course, be others. I would like to ask you at the outset whether you would like to make any general statement yourself by way of an introduction or whether you would like to go straight into the questions?

(*Dr Chalmers*) I will make a brief introductory statement, if I may, Chairman. The first point is that in submitting the written evidence and also in the comments that I shall make today I am doing so firstly from the point of view of the Museum, quite clearly. We are the country's leading systematics institution and it is quite right and proper that we should be responding in that way. But also our written evidence and our spoken evidence today will be from a wider perspective and that is we are concerned very much with the role of systematics in Britain and, more broadly, internationally because our Museum has an international impact. The second point I would like to make is that I believe, and indeed I am confident, that systematics has a central role to play in current biology. I am confident about its future, despite all of the problems that it has undergone in the past years and that is because I believe that it is an intellectually challenging subject, that it is an exciting subject of great scientific importance and of applied importance to humanity.

609. That is all you want to say, is it?

(*Dr Chalmers*) Yes, that is it.

610. May I just ask a preliminary question. Are your trustees apprised of this enquiry?

(*Dr Chalmers*) Yes, they are indeed.

611. Do your answers incorporate their views?

(*Dr Chalmers*) The answers are based upon the Corporate Plan which, of course, is approved unanimously by our trustees.

612. Did any of them wish to give evidence?

(*Dr Chalmers*) Not that I have known of. I have discussed this with the chairman and I think that we are the right people to give evidence to this Committee.

613. Thank you very much. We can now proceed to some of the questions that are in front of us and, as I said, others will arise. The first section deals with money, which is a key point to which you refer again in your own second edition of the Corporate Plan, of course. The first question arises on the reality of the figures which you have produced to us. How does one arrive at the £1 million a year additional funding that is needed—and perhaps I can expand this a little further because when I looked at your Corporate Plan I found even that was based on running a deficit over the years which you said constituted the nature of your bid to the OAL for extra funding. Have I understood that correctly?

(*Dr Chalmers*) The situation is, Chairman, that we specify and we state in our latest Corporate Plan that we require an additional £7.8 million over the 5 years of that Plan—that is on page 11 of that Corporate Plan—in order to maintain funding in real terms and to maintain our funding at its present level based on our best assumptions of inflation rates. If one looks at that £7.8 million, we estimate that approximately £5 million of that £7.8 million that we require will go towards science and the other £2.8 million will go towards other Museum activities. That is the way we arrive at the figure of £1 million for the year for science—£5 million over 5 years.

Lord Adrian

614. Could I just ask, are those real pounds or cash pounds? Is that plus £7.8 million in 1990 prices or 1991 prices?

(*Dr Chalmers*) It is cash.

Chairman

615. Following this up, I notice that something like 25 per cent of your income is to be generated from external sources.

(*Dr Chalmers*) Yes.

616. One first question is, of course, is that optimistic; is it realistic? More importantly, those external sources represent additional activities which if you are not making a profit from them, indeed if you are making a loss, are disadvantageous. If you are not making a profit they are work for nothing. How much do you make that you can plough back

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[Continued]

[Chairman *contd.*]

into the fundamental activities of the Museum out of that 25 per cent?

(*Dr Chalmers*) Firstly they are realistic figures. That is what we achieved in the last financial year. It was approximately 27 per cent. You are quite right that only a proportion of that is profit. Some of it generates equivalent costs. The proportion of profit varies very much from one activity to another. I think that it is fair to say that the great bulk of the scientific income is not profit.

(*Mr Legg*) I would agree with that.

617. It is self-balancing?

(*Dr Chalmers*) It is self-balancing.

618. Including the overheads?

(*Dr Chalmers*) In a few cases where we are talking about contracts, there are overheads. When we are talking about research grants, of course, there are not.

Lord Flowers

619. How much profit do you earn overall, never mind what category it is?

(*Dr Chalmers*) Can you give me an estimate on that, Dr Legg?

(*Mr Legg*) If we can go through the activities one by one. Shops and publications we make 10 per cent net profit to the Museum after all overheads. Catering is entirely profit. That is money from a contracting royalty. Functions cost us about £200,000 a year to run so we are making a 60 per cent profit on the turnover there. Admissions will be about £2.1 million or £2.3 million in the current year and they cost about a quarter of a million pounds in staff costs to collect. Curations and research we have dealt with. The Development Trust supports itself in terms of its running costs. The donations made to the Museum are entirely profit. Shared services and telephones costs are self-balancing. We run the telephone service for the three museums in South Kensington. The other income there is mostly interest from the money on deposit. That again is all profit.

Lord Porter of Luddenham

620. Could I ask a question, Mr Chairman. On the shops and publications which you mentioned, you are able to make 10 per cent. I see this year you actually got £2.5 million and you expended £2.2 million, which is a little more than 10 per cent. Is that worthwhile and does it actually cover all the effort that all the staff put into it? Have you costed the time of the senior staff and the effort that they put into making that 10 per cent?

(*Dr Chalmers*) I think, Chairman, one has to look at two very different activities there. With shops and publications, which are clearly commercial ventures—popular publishing especially—there is scope to increase the profit. That is something that we are looking at quite actively and indeed we will shortly be appointing a commercial manager to help improve the return there. Offsetting that at present are the academic publications which are not a commercial activity and which actually cost us. We believe in the future it is correct to regard that as a charge on the scientific activities of the Museum

rather than lumping it in with the rest of the publication activity. At present in the Corporate Plan, the total to which you are referring, they are not separated out.

Chairman

621. Now what will you do if you do not get on the recurrent side the bids which are in effect your deficits?

(*Dr Chalmers*) If we do not, there will be damage. That damage is spelt out in section 5.9 of the Corporate Plan which states that on the science side we will not be able to invest in the equipment and in the storage facilities that we require. We will not be able to invest in the information technology equipment and expertise that we need. We will not be able to make research appointments in priority areas that we require. So the damage is quite clearly spelt out in the Corporate Plan.

622. Are there any other resources which you think you can get to meet that shortfall from any other sources?

(*Dr Chalmers*) The sources that are available to us are firstly research councils, secondly the EC, thirdly—and this is something that we are looking at quite actively now—our Development Trust. We think it is right and proper to go out to potential sponsors and donors for them to support us for particular scientific activities. I have to say, though, that by and large most agencies, whichever of those I have just specified, would expect to find the equivalent of a well-found lab, that is, in our use, a well-found research institution, and would not expect to provide money for the basics which should be there—which are the collections, well-maintained, well-stored and a good IT capacity and so on.

623. Do you see the Office of Arts & Libraries as being the other side of your dual support, as taking the view it has a duty to help you to have well found laboratories which is part of the theory of the dual support system as it affects universities and research councils?

(*Dr Chalmers*) I think the OAL will have to answer for themselves whether they are familiar with that language. From my point of view I believe it is absolutely right the OAL should provide more funding for the Museum's activities and we, as a museum, should go out vigorously for funding from other sources, that is we should be seeking plural financial arrangements.

Lord Adrian

624. Has the OAL, since the transfer to it, maintained the real value of funding to the Museum or has it gone down? Is it now five years?

(*Dr Chalmers*) It was 1987 when we transferred. Since I have been at the Museum, which has been the last three years, the funding has barely kept up in real terms with inflation.

625. During that time presumably the income, particularly from admissions which is now, as I understand it, 1.8 million a year, has been an additional real increase?

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[Continued]

[Lord Adrian *contd.*]

(*Dr Chalmers*) Yes. We started charging in 1987, that is a real extra source of income to us.

626. If I recall correctly, and I have to declare an interest here as I was on the Board of Trustees until that time, at that time one of the things that charging was supposed to do was to meet the shortfall on scientific activity. What I am really searching for is why four years later the deficits, projected deficits, seem to be the same?

(*Dr Chalmers*) Costs in the Museum inflate more rapidly than our recurrent grant, that is true. In particular our salary bill is a very high proportion of our recurrent costs. We do not negotiate our own salary scales, they are negotiated nationally and we have to pick up the bill. We have, therefore, been obliged to pay substantial increases year by year and, frankly, admissions and other sources of income in the end cannot keep up. They can help to reduce the deficit but they cannot, by themselves, bridge that gap.

Earl of Cranbrook

627. Could I ask, are there any particular problems arising from the fact you are housed in the building which you find yourselves which is listed as of architectural importance and designed quite some time ago specifically for a museum when different ideas for museums were around?

(*Dr Chalmers*) There are a number of problems. The first one is the building is expensive to maintain and to refurbish. If you look at the appendix in our Corporate Plan you will see that is one of the biggest items on our budget. In relation to the budgetary items it is a separate sum of money, specifically for buildings, and the actual refurbishment and maintenance of the building has been, I think, one area where we have benefitted from our transfer to OAL because they clearly see it as part of their remit to retain the historical building in good condition. There is, however, another difficulty which is, of course, running a major research institution in a Grade 1 listed Victorian building presents its problems. It is difficult to get the best arrangement for one's storage and information technology has to cope with the architecture, if you like, health and safety regulations are becoming increasingly stringent, and rightly so, but they are more difficult to enforce in a Victorian listed building than they would be in a custom built late 20th Century building.

Lord Flowers

628. May I ask what is the nature of the discussions you have each year with the OAL about what your core funding should be? Is it just based on the historic approach, you take what you had last year, add something to cover inflation and say there are a few things you want to do for the first time and it all adds up to this and then you have an argument?

(*Dr Chalmers*) We separate recurrent costs and capital costs first in our argument. I should say last year when we submitted our Corporate Plan, which was a radical departure from the previous Corporate Plans, it was not just a question of looking back at historical precedent and adding a percentage, we went to great pains there to define our core activities.

Our Corporate Plan, and we have said this quite explicitly to OAL, particularly in the covering letter I wrote to Charles Henderson, describes the activities of the Corporate Plan within the Museum, there is not a subset which is central and the rest is peripheral, that is the core of our activities we wish to be maintained by OAL. We will be saying you need to maintain our funding, our recurrent funding, at a level year by year in real terms, we cannot go on having our funds pared away. It was placing an impossible strain upon us.

629. You have taken a leap forward and you hope that an historical approach will now be more sensible?

(*Dr Chalmers*) It will not be a lightly taken historical approach, we will argue cogently for a programme of activities but we will by and large be saying this, at the moment, is the core of the activities we are supporting.

630. What is the nature of the discussions you had with them? Never mind the sum you got out of it at the end of the day, do you feel you were having a sensible discussion about your problems with OAL? I ask this because they are not accustomed to being half of a dual funding system as many other bodies are.

(*Dr Chalmers*) I have to say we did not have detailed scientific discussions about the scientific merits of our arguments with OAL. They could not put themselves up to that kind of discussion, if you like, they would not feel they were competent so to do, to have that kind of discussion. They did have a scientific adviser at at least one meeting we had with them drawn in from another department to hear and discuss the plan with us.

631. Who was that?

(*Dr Chalmers*) It was the Chief Scientist from another department.

632. It was a Chief Scientist, was it?

(*Dr Chalmers*) I can let you know the name of the person afterwards but I cannot think of it off the top of my head. It was a lady but I cannot recall her name.*

Chairman

633. May we return to the sums you have put forward in view of the statement you have made. I notice that the bid plus your expenditure, which brings your total expenditure you hope for and total income, only increases by something of the order of 4 per cent a year in cash terms according to your own prospect. In view of what you have said, particularly about salaries and the difficulties there and the way inflation has been going on the scientific research, is that a factor or does it mean you are really going to be contracting activity?

(*Dr Chalmers*) One has to separate out the buildings expenditure, which is very lumpy, —

634. I am referring to the running costs only.

(*Dr Chalmers*) If one looks at the curation and research we are talking about a change from £9.8

* Note by the witness: The lady was Dr Elizabeth Cottred, who was the Minister's Political Adviser at the time.

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[Continued]

[Chairman *contd.*]

million in the current financial year to £12 million in 1995-96. I cannot work that out in my head.

Chairman: It is 12 per cent.

Lord Porter of Luddenham: 10-12 per cent.

Chairman

635. 12 per cent, it is about that.

(*Dr Chalmers*) Very well, that is a conservative growth rate.

Lord Flowers: Very!

Chairman

636. In that activity, yes, but that is crucially dependent, of course, on you having the bids meet the ability to carry that out?

(*Dr Chalmers*) Yes, it is crucial we get those additional bids.

Lord Flowers

637. May I ask who advised you what rate of inflation to put in?

(*Dr Chalmers*) We took two sets of figures.

(*Mr Legg*) We took the published Treasury forecast and also advice from our own business trustees who made a best educated estimate. We could analyse our main items of expenditure.

Lord Adrian

638. Were those estimates borne out?

(*Dr Chalmers*) Ours were somewhat above.

Earl of Cranbrook

639. Can I ask, Chairman, whether or not the Treasury imposes any efficiency element in its forecasts for your grant in the same way as it does on other non-Departmental public bodies; that is to say, a forward reduction due to assumed efficiency schemes?

(*Mr Legg*) Not overtly but together with the percentage increase in the running costs, grant-in-aid each year is less than the rate of inflation, particularly the rate at which pay increases rise. Then there is an element there which is pushing down our grant in real terms and therefore we have to make other efficiency savings.

Earl of Selborne

640. From the grant-in-aid which is given you from the OAL, are you able to identify some sort of sum specifically awarded because of your curation and research programme?

(*Dr Chalmers*) No. The grant we get from OAL is divided into 3 bits. There is a general running costs grant which is not sub-divided at all. It is up to the trustees and senior management of the Museum to apportion that between science and other activities as they see fit. The second segment of the grant is a purchase grant which is to buy items for our collections. That is of the order of £200,000 a year. It is adequate for our needs because by and large the objects in our collections are donated. We occasionally have to make purchases, let us say of a gem here or a particularly valuable specimen there,

but that is a fairly small item for us; and the third element of the grant, as I have mentioned before, is the buildings grant.

641. If we can look at the further sources of income which come within the category of "self-generated", clearly the income which is described as curation and research is specific grants awarded for specific research?

(*Dr Chalmers*) Grants and contracts, yes.

642. The income of the Development Trust appears to be fairly static over the next 5 years. Would any of those funds be specifically ear-marked for research?

(*Dr Chalmers*) The answer is yes. I should explain that the Development Trust was formally launched in October 1989 and a policy decision was taken then to concentrate initially upon raising money for exhibitions because it was felt it would be easier to do that, frankly, than to raise money for scientific research. A few donations were made for research—and very welcome they were too. We have now reached our original target of £5 million for the Development Appeal and we are going into a second stage where we are quite explicitly putting in major projects for the support of science.

643. Nevertheless, your Corporate Plan projected income does not appear to increase for the Development Trust?

(*Dr Chalmers*) The £5 million which is what I have referred to, is spread over that period. We are now in the stage of planning our fund raising campaign for science. I think the appropriate time to put the figures in for that scientific support will be at next year's Corporate Plan when we hope to have an uplift of the figures there.

644. I understand that the second stage of the Development Trust you anticipate will raise further sums for curation and research. You have not allowed for that in the Corporate Plan because you have not thought of that yet?

(*Dr Chalmers*) We have not reached that stage yet.

645. Do you set targets for what you might achieve from the Development Trust?

(*Dr Chalmers*) At the moment we have identified areas where we believe the support will be most forthcoming and we have set ourselves very broad targets in two or three areas but there is further work needed there.

Chairman

646. Is the principle to spend as you raise or are you hoping to raise a capital sum ultimately upon which you can preserve and use the interest?

(*Dr Chalmers*) I think both of those approaches would be needed. In some cases we would hope to set up an endowment, let us say, to fund a particular project decision. In other cases we aim to get support for a particular research project which a company, let us say, would be prepared to support year by year.

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[Continued]

Earl of Cranbrook

647. The Museum has consistently linked curation and research. What we have heard about and seen for ourselves is the enormous backlog of curatorial tasks which will require considerable expenditure. I wondered to what extent the OAL might recognise that the care of the collections was very much the same as the care and maintenance of the building and thus something which could be usefully separated out in budgetary terms and something that could be regarded as an overriding OAL responsibility if it was separated out from your research programme?

(*Dr Chalmers*) I cannot answer for OAL as to how they would respond. From our point of view I do not want to see a separation of the funding for curation and research from two different agencies. I think, if that is what your question is leading to, that would cause grave problems. It would be divisive. I think one funding department would play us off against another. I think there would be many areas of curation and research where it would be difficult to know into which area it should go. I would far rather we presented the case to the OAL that our proper activity at the Museum is scholarship based upon the collections and that is what it should be supporting.

648. One of the major criticisms of your staff reconstruction has been is that you have in the Museum separated curation to a great extent from the pursuit of research. I find your answer is somewhat non-matching with your actions.

(*Dr Chalmers*) I think funding by two separate agencies would produce a massive separation which would be quite unhelpful to the Museum. Let me, if I may Chairman, explain the relationship as I see it between curation and research for the Museum. Both are intimately linked; there is no doubt about that at all. They must reinforce each other and curators and researchers must work together.

Chairman

649. Are they sometimes in the one person?

(*Dr Chalmers*) That has been the practice in the past. What I believe is right for the Museum and what the Trustees believe is right is that curation is recognised as a challenging and proper activity in its own right in the Museum. I believe that in the past it has too often been relegated to a second place, if you like, a second-class activity in comparison with research. I think that is profoundly damaging to curation. If you look at curation there are a whole range of activities which it incorporates, from routine simple tasks like filling up bottles with spirit or fumigating insects or whatever through to major management decisions about the running of the collections of, let us say, 20 million insects. What is your policy going to be on that? What is your data processing policy going to be? Senior curatorial posts should be, and now are, seen as challenging creative posts within the Museum and it is right to have a career structure where people can value curation in its own right. Having set up a structure like that, which we have, it is vital that our curatorial staff work closely with our research staff who themselves will be intimately acquainted with the collection because they have worked on it. But the researchers will pursue their research programmes knowing that

that is their primary activity. I should say that the system to which we are moving is one which is found in very many of the other great natural history museums of the world where there is a separate "collections" career structure where you have collections managers and then you have researchers working closely with them in teams. That is what we are aiming for.

Chairman: This is almost going back, I think, to Lord Cranbrook's point that you separate curation and research as line items in the budget.

Earl of Cranbrook

650. It seems to me, Chairman, exactly as you have said, that it is confusing to have the functions and the staff separated yet a budgetary line continuing as a unit.

(*Dr Chalmers*) It is perfectly possible, and will be, as the system is now put in place, and it is just about in place now, to separate out the curation and research as line items in the budget. What I do not want to happen is to have one of those line items funded by one Government department and another line item funded by another. It will be grossly disadvantaged by that arrangement.

Chairman

651. I think you possibly know the views of the Select Committee even on that kind of separation in relation to the recent report we produced. To return to the problems of the nature of staff engaged in this, over the last eight years you have reduced staff to by about 150 from 780, I take it that is total staff?

(*Dr Chalmers*) Yes.

652. You also refer to the fact that this is going to make room for you to employ temporary staff?

(*Dr Chalmers*) Yes.

653. One of the points made to us, not once but many times, is curation depends upon very long experience in particular. Could you explain how you deploy people who are permanent and temporary between the activities of curation and research?

(*Dr Chalmers*) The bulk of people on temporary terms are research fellows. I think it is important that in the Museum we have a balance between people who are on permanent terms and people who are on temporary terms. That balance, one could make a guess at what is right, certainly the number of temporary appointments has risen over the last financial year by about 30. I believe that certainly before the changes that we are talking about we had too few people on temporary appointments. For the good of the Museum you need a throughput of vigorous, lively, young people who can contribute to the museum and we are achieving that. However, to get back to the point you made, I do not see those people developing the experience to carry out the long-term curation. You need people working on those collections for many years, so you need the substantial majority of people on permanent terms.

654. May I pursue this a little further and ask could you supply us with the figures you have for present staffing under these headings, curation, research, permanent and temporary? I recall going round when we visited the Museum and what was called the Spirit House?

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[Continued]

[Chairman *contd.*]

(Mr Peake) The Spirit Building.

655. Where one was seeing to what you adverted in your evidence about topping up bottles with alcohol. I was talking to the person curating there and there seemed to be no-one coming on following. Are you happy that the expertise which exists will be handed on in the right amounts to people for the future to preserve the continuity of knowledge and expertise?

(Dr Chalmers) If we can take the first question about the numbers of staff.

656. You can write it in if you wish.

(Dr Chalmers) We will provide it in writing, we will be happy to do that. In terms of the supply of young people who come in as junior curators, if you like, we are recruiting in certain areas now. We have recently recruited five entomologists at the most junior level, ASOs, Assistant Scientific Officers, and as we have the funds we will want to put in more. It is a problem. There are two problems, one is the funding one, do we have the amount of money we need to put those people in and, secondly, is there the interest among young candidates of sufficient quality to come in and take up those jobs? Then there is the question of training which you will no doubt come to.

Lord Porter of Luddenham

657. Could I ask Dr Chalmers to tell us about the research fellows, the temporary posts, are they funded from the same source as the permanent staff or do they come from one of the research councils?

(Dr Chalmers) Both. We put some of our own grant in aid towards temporary posts and we also are getting research fellows again through research council grants.

658. When you say dual funding for the Museum split between OAL and DES would be unacceptable, it is actually happening, and the more you give to temporary staff the more it will happen.

(Dr Chalmers) I would say it is unacceptable as a permanent arrangement whereby you have a certain chunk of money, as it were, grant in aid from one department for curation and another for research because things will fall between the cracks. What I would far rather have is core funding for our science, an adequate amount of core funding from one Government department and just vigorously going out and garnering other research funds from whatever source we can.

659. Which is one of your reasons, presumably, for preferring the OAL support, because it does give you dual funding? If it were DES support from the start that would be it, you could not go to OAL for your research fellows.

(Dr Chalmers) You are right. One of the most valuable things that arose from our transfer to OAL was our ability to apply to research councils for finance and that has been gratifying in that we are now getting substantial resources, particularly from NERC and SERC.

Chairman

660. That was coincidence in the timing but not necessarily a possible break in principle?

(Dr Chalmers) It was ---

661. 1987 was the date but in principle it could have been negotiated earlier on if you so wished?

(Dr Chalmers) It could have been.

Chairman] The science vote could have divided it into core funding and the rest.

Lord Adrian

662. Could I ask, you say you have over the last few years markedly increased the number of young research people on fellowships, what is their subsequent career when they leave the Museum because we have been told in other evidence sessions there is a sad lack of jobs in systematic biology but also there is a sad lack of people who are trained in systematic biology in schools and universities and so on? I wonder (a) where you find these people from and (b) what happens to them when they leave the Museum?

(Dr Chalmers) Where we find them from? It is true to say, and John will amplify this, we get our research fellows in two particularly active areas. One is molecular systematics, which you might expect to be lively. There are a lot of people around and the Museum is an attractive place for people to come to. The other is not of interest to this Committee because it is in the mineralogical field. We are getting people with a chemistry background coming in to work with our mineralogists and work on the structure, the crystalline and atomic structure, of minerals. Both of those are in a vigorous and quite large area of activity. In the more conventional areas of systematics we are finding a small supply of people coming in but there is no doubt they are worried about where they can go, just as a lot of people are in universities who are on short-term contracts. I do not think this is a unique problem to the Museum, it is actually a problem with British science.

663. Do you keep any records of where they go?

(Dr Chalmers) We shall do. Because we have only recently moved into this way of working rather few of them have yet gone.

(Mr Peake) One or two are absorbed, that we employ ourselves but most of those who go outside—the majority I would have said—leave biology to my knowledge. One or two go into jobs elsewhere in biology.

Lord Adrian

664. Would it be true to say that the new employment structure on the research side in the Museum is not actually helping to supply the systematic biologists to the economy where we are told they are very important?

(Dr Chalmers) I think at this very moment you may be right. To return to a comment I made right at the beginning, I believe that we will see a change in the perception of the importance of systematics over the coming 5 years for a number of very good reasons. That I believe and hope will lead to an upturn in the number of jobs available for systematic

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[Continued]

[Lord Adrian *contd.*]

biologists. I am referring particularly to the concern for the environment. As everyone in this room well knows, there are major political discussions at an international level about the conservation of biological diversity leading to an international conference next summer in Rio de Janeiro. This in itself is an indicator of major political concern about the natural environment. There is a clear role for taxonomists and for systematic biologists in conserving the world's biological diversity and I believe that a limited number of jobs will flow from that.

Chairman

665. That brings us back, I think, to the financial point again. If that is the view then perhaps one might be looking—as indeed one of our questions presupposes—to the possibility of funds from outside this country to help the Natural History Museum in its financial problems. Do you foresee, for example, as a consequence of what might be UNEP or other bodies, the possibility that the Museum might in fact be a major contractor, research grant receiver from external funds or even perhaps that part of our aid to developing countries might take the form of contracts from the ODA?

(*Dr Chalmers*) I think the ODA in particular is one source of funding that is going to be important especially in the environmental area. It is one we are actively pursuing. I have already mentioned the EC already and UNEP is a third. Would you like to add any comments, John, about any other agencies? The principle I totally agree with that we should be looking to a wide range of international funding.

(*Mr Peake*) We have talked to international agencies but I think one has to make the comment that they depend on a well-found laboratory and core funded areas. They do not provide substitution money; they provide additional money in most cases.

666. Part of your argument to the OAL at the present time could be, "Unless you invest in us, we are not able to secure these external monies." Has that argument been deployed?

(*Dr Chalmers*) In principle that is an argument we have made. I have used different words but that is the argument we have put.

Earl of Cranbrook

667. In the United States, by comparison, your sister organisation there would also expect a great deal of funding from private charitable sources and private foundations. You might also expect such funding in this country if you were a museum of the arts. Do you feel that there is any way in which you can tap such sources as a natural history museum in the United Kingdom?

(*Dr Chalmers*) Yes, I think I have alluded to that earlier in some of my answers. We are currently having discussions with a number of companies, for example, about supporting our science and several major companies have expressed more than passing interest. I think that is going to be a source of funding for us in the future. I think one of the problems is that the tax advantages which one gets in this country for making donations are much less generous than they

are in the States. I think it would be a real help to us as a museum, as it would to many other institutions, if there were greater concessions to donors and sponsors for supporting sciences.

Earl of Cranbrook: I recollect that there is a large concession available now this year, by which any gift over £600 gets immediate and full tax relief for the year of the gift.

Chairman: I think you may not be fully informed on the relative positions of the States and here because one has heard the other evidence, of course.

Lord Whaddon

668. Dr Chalmers, we have spoken of the research fellows and where they go after their term with you. Where do you source them? Where do they come from?

(*Dr Chalmers*) They come from universities and research institutions.

669. All United Kingdom?

(*Dr Chalmers*) No, from around the world. That is not a casual comment. Increasingly we have to look for highly qualified and highly skilled research systematic biologists from around the world because the supply is not forthcoming from the United Kingdom.

670. Do you find that the supply from the United Kingdom at the level you require is decreasing?

(*Dr Chalmers*) I think that is true.

(*Mr Peake*) In looking at the applications from systematic biologists that we get, we have a good number from the United Kingdom but I also have to say they are coming from the world, from a wide range of countries, and particularly from people who have been trained in the US.

Lord Porter of Luddenham

671. That is the point that has been in the back of my mind several times in the last half hour. Dr Chalmers, you talked about molecular systematics when you were talking about your fellows. Mr Peake has just talked about molecular biology. Am I right in supposing—let me exaggerate it and then you can say no—that the whole centre of gravity of systematics is shifting towards molecular systematics and that is the way that it is going to go. If that is the case, when we were talking about the availability of fellows and where they were going to go afterwards, are we not talking perhaps about two kinds of people; the molecular biologists and more traditional systematists?

(*Dr Chalmers*) I would say that it is an exaggeration to say, as you have said, that the whole weight or focus of systematics is shifting towards the molecular level. I think the systematic biologists in our Museum would say that it is a welcome added dimension to their work and has to be incorporated into the whole theory of systematics about how they classify and assess relationships between organisms. It is not going to swamp systematics. Systematics, if you like, is a theoretical framework and you can look at molecular characteristics in the same way you can look at more conventional morphological factors. That is one end which is, if you like, a scientific one. I think from another point of view there is a kudos.

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an interest in molecular biology which is so great that there is a tendency for that to dominate all of biology, not just systematics. I think we have to be very aware of that in the Museum and not let molecular systematics become, as it were, such a dominant band wagon that nothing else can survive.

672. "You would say that wouldn't you", if I can put it that way because the majority of those in the museum are of the non-molecular biology kind?

(Dr Chalmers) Yes, but there are people –

673. So they are defending their territory.

(Dr Chalmers) There are systematic biologies in the Museum—indeed I know at least one is sitting in this room—who welcome the opportunity to incorporate molecular knowledge into their more traditional morphological framework.

Chairman: You showed us a set-up when we were there.

Earl of Selborne

674. You made it quite clear and I think we must accept it is for the government to produce the funds for a well-founded laboratory but your success in attracting extra funds will depend on the core funding being in place. Your problem appears to be that the grant-in-aid from the OAL will never be enough for what you would have said is a well-founded laboratory. In the case of the Waterhouse when you have specific funds which you have earmarked. Would it help you and your trustees to have funding for a well-founded laboratory ear-marked in the same way or would that be restrictive?

(Dr Chalmers) I think it would help us to have major capital projects, let us say a specific new laboratory facility, identified and bid for. I do not see that it would necessarily be to our advantage to have ring-fenced, as it were, the whole of our scientific work. I welcome some flexibility in moving the funds around the Museum from one area to another year by year. I do not want the Government department to say: "This is the sum of money that you will have within a particular function of the Museum, like science, and you should bid for that separately against exhibitions or whatever".

Chairman

675. Provided you get the protection at the end of the day, and power to use it as a block grant, all that can be covered. You bid for it under items, as indeed universities are financed on a formula basis now, but when the money comes you can use it in whatever way you wish within the broad terms of your mission, to use the current jargon. I think that is standard practice.

(Dr Chalmers) I am anxious to avoid having a series of separate battles over a series of separate line items in the budget.

676. And how you maintain it and spend it?

(Dr Chalmers) Yes.

Chairman: We have to leave finance soon but it is so crucial there are a number of questions one wants to ask. One point is question nine in those questions sent to you, systematic biology in the USA: the NSF does fund that separately and makes grants to bodies

like the Natural History Museum here. That brings me on to the earlier question, question six, how we compare generally with the USA, on which Lord Flowers has some questions too.

Lord Flowers

677. I just want to ask this because international comparisons are very important because at the end of the day how do you know how long a piece of string is until people cut it with whom one is, in a sense, in competition. I wondered how you did in museum activities and research activities separately, as far as you can separate them, compared with other countries notable in systematics, Australia, the USA and so on, and whether you had done a systematic study of these comparisons?

(Dr Chalmers) I have several questions to respond to there. The simplest one: have we done a systematic survey of the financial arrangements in different countries? The answer is no. Of course, each is different, some have a federal system superimposed upon a state local system and so on. Do we favour the state systematics research fund as occurs in the States? Superficially I think that is an attractive idea, you feel there is a study fund to which you can apply as a museum and have a high probability of success.

Chairman

678. There is a state one for curation too from the National Science Foundation.

(Dr Chalmers) I think, however, there are problems and I think one should be aware of that. I want to see systematics as a strong discipline within the biological sciences equally accepted on a par with molecular biology, genetics, ecology, embryology, all the other disciplines. I want to see systematics interacting actively with those disciplines, I do not want to see it shut off. What I want is applications to research councils or other granting agencies from systematic biologists treated on their merits equally with applications from other areas of science. That is surely all one could ask for otherwise why is one protecting a discipline that does not deserve to survive? As I said at the outset, I believe systematics is profoundly important and it can stand on its own against other disciplines. I ask for that assurance and, indeed, in talking to Sir David Phillips, the Chairman of ABRC, he has given that assurance and we are beginning to show systematics can stand on its feet and compete with other disciplines. I think that is the way forward.

Lord Flowers

679. And compete with other countries? You have not really answered my question.

(Dr Chalmers) I find it very difficult to judge how we compare with those countries listed down in question six. Australia is much smaller than us, they have a state system and CSIRO and so on. France has a system whereby they produce enormous sums of money occasionally for vast projects from their national resources. I find it very difficult to judge how we do. The great difference, if you go around to the big American museums, and I hope this Committee will visit some of those museums, is there are very

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substantial funds available from sponsorship, from donations. If one takes as a specific example the American Museum of Natural History in New York, they have a certain amount of city and federal funding and a very large proportion of funds from private donations.

680. Could I ask what the evidence is that in the past research councils have not judged systematic biology fairly?

(*Dr Chalmers*) It is anecdotal. We were only eligible as a Museum to apply from 1987. It is corridor talk, if you like. One talks to members of panels and committees and the suspicion was applications for research grants in systematics were not looked upon with great favour in comparison with those from other areas of biological sciences.

681. Has a study been done in terms of the number of applications and the amount of funding and the number who have been funded and so on? It is an important point, and one that is so important it is difficult to rely on, as you say, corridor gossip.

(*Dr Chalmers*) The most important point, as far as I was concerned, was the assurance I was given by Sir David Phillips last year about the applications from biological systematics being treated on their merits and equally with other areas of science. I think once we have been in the business a little bit longer—we are very new to it I have to say—that will be the time for the survey, but the sample size will be small at the moment.

Chairman

682. We have had a lot of evidence from many witnesses on the state of systematic research generally, this is not just the Natural History Museum but the whole community, that the general activity is in a depressed state in terms of securing grants and so on and suggestions have been made by several people there ought to be something which one witness called a Board of Systematic Research which would take an overview position and perhaps develop policy. I do not know whether you are aware of that or are being told that for the first time. Have you got any views on that?

(*Dr Chalmers*) I have in a sense, I think, answered that question. I am aware of the suggestion about there being a systematics board. I believe in the long run it will have the undesirable effect I have mentioned of reinforcing a barrier around systematics and giving it protection that in the end will not be helpful. I challenge your statement that systematics in the Natural History Museum is in a depressed state.

683. I did not say that, I said others have given evidence that the state of systematics generally is in a depressed state.

(*Dr Chalmers*) That may well be true country-wide. I believe the reason is systematic biologists have not adequately addressed the question over the past years about what is the most important contribution they can make to fundamental science and what are the most fundamental contributions they can make in terms of applied science. They have not set priorities and they have not, in the end, gone

out and been vigorous advocates. That is what is essential.

Lord Flowers

684. Chairman, could I be very blunt because we are trying to get to the root of the matter. Everybody working in science in this country claims that they are under-funded—under-funded compared with what they used to be; under-funded compared with other countries. Then if you go to these other countries they say exactly the same thing—they are under-funded too compared with us and so on. So there is a general state of under-funding and this is something to do with the growth of science and sophistication and all that. You are claiming that you are particularly under-funded, as I understand you. Are you really worse off than anybody else in other fields? Are you really worse off than others in the same field in other countries? What is it you are really saying is the matter with your funding?

(*Dr Chalmers*) I have not made a claim that we in the Museum are particularly under-funded. What I have said to OAL, and I say to you as a Committee, is that we have identified a core programme of activity that requires level funding. We have taken responsible action to make sure that our systematic biology will have the greatest impact possible in the future. I do not go around, by and large, saying simply, "We need more money." I think that is going to have absolutely no effect whatsoever—a simple statement of that sort—in the current political climate. You have to identify it by setting clear priorities and what we have done as a Museum is to say, "These are our priorities in science, which is the reason systematic biology is important. This is where we will concentrate our effort and this is what you the OAL ought to give to us to support us and we will go out and get the rest ourselves."

Lord Flowers: I thought that was what you were saying but I wanted to be absolutely sure.

Earl of Cranbrook

685. Can I ask whether the targets of systematic research ought to be the same sort of targets as those that are set for themselves by research councils. For example, some of the statistics we have been given show us that perhaps only 3 per cent of the nematodes likely to occur in the world have yet been discovered and been named. Would a systematist look at that list and say nematodes are an area where there is an enormous gap in our knowledge? Some other large groups—mites for instance, are a group people have not tackled and there are hundreds of thousands yet to be discovered. These may not sound to research councils like innovative research. It seems to me that you are trying to set your systematic priorities within the research councils' priorities. Would there be a genuine kind of target systematists ought to see, in order to build up the knowledge of the total biological diversity, which would not necessarily be geared to the kind of priorities that you have chosen?

(*Dr Chalmers*) I think a blunt answer is no. Let me see if I can amplify that. It is clear that the task of describing and naming and classifying and working

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out the relationships of all living organisms, let alone possible organisms, is so massive it is beyond the world-wide capability to do that. One has to be selective. So if one is looking at where one puts one's effort as a systematic biologist or as a member of a research council panel or whatever, you have to decide, "Why am I going to select nematodes or mites or some other group of organisms as opposed to others." You have to have some criteria. I believe you make those selections either because the organisms you choose are helping you address a particularly important scientific problem. Why are some groups particularly speciose and some not? Why are others distributed geographically in a certain way or over time in a certain way? Or you choose your organisms for practical reasons because they carry disease or are pests.

Chairman

686. Before we go on with this, can I interject at this point and say I have in front of me your key objectives for science. The second one says "Research—to develop basic and applied programmes relevant to contemporary needs and issues". That is a rather odd statement in a sense because basic research by definition is not related to contemporary needs and issues. Is there room and is there space within your forward plan for that kind of basic research which is generated by the needs of the subject alone and the opportunities which are presented to you, that is basic research as it is generally understood, curiosity motivated?

(*Dr Chalmers*) I would deny the contradiction. I would argue that contemporary issues include matters of contemporary basic scientific concern.

687. It might be as well to make that clear if that is a document that is going to be read by those who are going to give you money.

(*Dr Chalmers*) Let me amplify my answer. I believe that for a museum there must be a balance between basic curiosity driven research – If you look at the titles of our research programmes you will see there are clearly curiosity driven research programmes on the one hand and then applied science on the other. We put money and emphasis upon the highest quality of basic science. You should know that, for example, we now have something like 16 per cent of our researchers who are what are called individual merit promotees. That is a high percentage. That is the equivalent in university terms of a university personal chair. Those are people who have reached that rank in their peers' view in a system that covers all the research councils and ourselves and they are recognised as IMPs because of their research excellence in basic science and they are addressing problems of contemporary interest to science.

688. Yes, I see. Thank you very much. That is very helpful. Can I ask one further and final question on finance because we must leave it some time. Somewhere I noticed—I cannot remember where—a reference to the fact that you had thousands of enquiries per annum. It suddenly struck me that if one were a private consultant charging £500 per enquiry the problem of your shortfall would

immediately be resolved if thousands means literally 2,000 or more. Do you charge for your services or is much of this enquiry in fact normal exchange between comparable institutions or universities or museums and so on?

(*Dr Chalmers*) I will ask John to reply in detail but I would say the principle is that where we do not see reciprocal benefit we charge. Where we do see reciprocal benefit, with universities and other museums, we do not generally.

(*Mr Peake*) I can show 3 clear groups in answer to you. There are public enquiries from naturalists, from people just curious about various problems they have got. We do not charge those people. They are the general public. There are two other classes I can see. There are academics where we can in many instances see reciprocal benefits and we do not charge there. There is a third group where we can see there is clear commercial gain or it is related to commercial activity and there we do charge quite clearly.

689. How much do you raise by this last category?

(*Mr Peake*) In enquiry services it came last year to about £90,000. We might be able to increase it but it is still going to be comparatively small. Most of our enquiries come from the first two groups.

Chairman: So there is little hope of balancing your budget by that means.

Lord Porter of Luddenham] Unless, my Lord Chairman, one extends it almost to the point of charging for enquiries by the House of Lords Select Committees!

Chairman

690. Yes, that is something on which I cannot comment and the Clerk is notably silent! Perhaps we ought to move on to some of the other questions, unless my colleagues want to continue on the funding. May I just ask at this point are there any other aspects of funding which have not been covered either in our written replies or your Corporate Plan which you would like to bring to our notice because in a sense we have been very conscious of the problems that you have had to face as a result of this change in funding?

(*Mr Legg*) One point which perhaps we have not made clear, Chairman, is that as far as our buildings grant is concerned as soon as we transferred our sponsorship from the DES to the Office of Arts and Libraries that has increased considerably the overall level that was generally available from the DES.

691. You have not thought of separating your function? For example, it has been suggested I think in one article in *The Spectator*, with which you must be familiar because it was so extreme in its terms, is there any sense in the notion of separating the exhibition theme park activity on which it commented, if it exists, from the other and outhousing that somewhere?

(*Dr Chalmers*) I think not, Chairman. I think you have to see the Museum as a corporate body where the education and entertainment side on the one hand interacts with the serious research and curation on the other and both strengthen each other. We are immeasurably stronger for having two sides of our

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work in the same institution. That is not something we want to see happening.

692. It is even from a structural point of view given your problems. The programme calls for outhousing for other purposes rather than exhibition purposes.

(*Dr Chalmers*) Quite so.

Lord Flowers

693. Quite apart from your present preference would there be any net saving if you were to separate them?

(*Dr Chalmers*) That would depend very much upon the terms of the separation. Frankly, if one was running two separate institutions, two separate administrations and two separate structures, I suspect you would get a duplication of effort that would add to the costs rather than reduce them.

(*Mr Legg*) That may well be true.

Lord Porter of Luddenham

694. But, of course, you would move, in those circumstances, your research out of London altogether?

(*Dr Chalmers*) Quite so. That is why I said it would depend very much on the terms under which we were able to use any money released by such a removal.

(*Mr Legg*) And too what the redevelopment opportunities for the site in South Kensington would be if the collections were removed from that site.

Chairman

695. Could you tell us now, coming back to the intrinsic activities of the Museum and your stated desire to see classificatory systematics and molecular biology brought together, in relation to your collections the power of the computer in both cataloguing and what have you? I think you make the point about the library and its cataloguing of the collections, that they are needing to be listed if they are to be made accessible quickly. What lead is the Natural History Museum giving to the community in the matter of the computerised data bases which you have and drawing in information from other sources? What part do you play internationally, or do you expect to play?

(*Dr Chalmers*) The computerisation of our information, of our collections, is a massive task and one must not underestimate it. We are active and selective, I think those are the terms I would use. We are, for example, putting in an ethernet so we can network all our facilities across the Museum. We are in the process of doing that.

696. What did you say?

(*Dr Chalmers*) An ethernet, it is a simple communications network whereby any computer in the museum can talk to any other computer in the Museum.

Lord Flowers

697. Local area network?

(*Dr Chalmers*) Yes. Users can talk to each other through their computers rather than having isolated computers dotted round the Museum. We are selective in that we are developing computerised data bases in particular areas. We are working with the World Conservation Monitoring Centre in Cambridge on a European plant data base, and some of you may have seen that on your visit. We are working with the Missouri Botanical Gardens on the Flora Mesoamericana project which is to name and identify the entire set of vascular plants in Central America.

Chairman

698. You are working jointly with Kew?

(*Dr Chalmers*) No, with the Missouri Botanical Gardens and a university in Mexico.

699. Is that because of this curious division?

(*Dr Chalmers*) Yes, the Morton Agreement. We have a network system in palaeontology up and running and in mineralogy we have a new computerised data base as we merge two distinct collections. It is often put: "Why don't you put your entire collection on computer" but one wants to realise the scale of that problem. Some calculations we have done suggest, firstly, we have 67 million objects in our collections. We are, as I said, putting some of those important items on to the computer. We know the rate at which we can do that. Extrapolating the 67 million objects we calculate it would take 1,500 person years to achieve that at a conservative cost of about £50 million. Is that kind of effort and expenditure justified? It is very difficult to justify it in terms of the sums of money we have been talking about over the last hour or so. It is of a different order of magnitude.

700. But it need not be reduced to that particular degree if you already have a system of sub-classification and if you reduced it by a factor of ten?

(*Dr Chalmers*) It depends if you are going to have what one eminent biologist called a "quick and dirty catalogue" or have a complete record. You are right, you may want to get a subset of the information and run through that. The real question is to identify a reason why you want to put things on a computer first and go over the system which helps you pursue that goal. At the moment we have identified a number of key areas where we say it is very important we have this particular collection or types or whatever on the computer and we will concentrate on those areas.

701. At the end of the day in relation to the problem of biological diversity, to which you referred, any such system which you have has to be compatible with the systems adopted in other parts of the world for their areas, is that not so?

(*Dr Chalmers*) Yes, that is absolutely right. It is coming.

702. It is coming.

(*Dr Chalmers*) Since I have been talking recently to people at the Missouri Botanical Gardens I know it is particularly advanced in the plant area.

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[Chairman *contd.*]

(*Mr Peake*) We are talking and our people are serving on international committees looking at the data structures and data transfer between different areas of the world. There have certainly been massive agreements within the last few years. Within the United Kingdom, museums are looking very much at their data standards and how they transfer. There is a study going on at the moment. Again we are collaborating with Australia, I am looking at their data structure and compatibility between Australia and United Kingdom. In looking at the data bases there are two different problems, one is the data base of our collections and the second one is the data base on biological diversity in the world. That is the first division and they do not have to be the same. The second is having developed a data base and developed a package of tools to enable you to address and analyse that data base and bring forward a wider range of information from it; analytical tools.

Earl of Cranbrook

703. I wonder whether there ought to be any priority on building up a data base on a national basis, rather than *Flora Mesoamericana*?

Earl of Cranbrook

704. A national database of United Kingdom biodiversity?

(*Mr Peake*) I think in parts of it we are. We have done that for some groups, but we have not done it overall. I can see advantages in doing it. One research group is moving interact towards a greater analysis of diversity in the United Kingdom. I think it is easy to see, and it is feasible in the terrestrial environment, but it gets harder when you move into the marine environment and into fresh water.

Earl of Selborne

705. Would a programme such as that be something you might apply to NERC for a grant for.

(*Mr Peake*) I think it might be.

Earl of Cranbrook

706. It could attract the public imagination?

(*Dr Chalmers*) Quite possibly, for natural history enthusiasts it could do.

(*Mr Peake*) Could I made one defence of *Fiona Mesoamericana*—I think it is an area of high diversity and great interest to the world.

Earl of Cranbrook: I would not like to be on record as being in any way derogatory about middle America or the other way round!

Chairman

707. Dr Chalmers, we have asked an awful lot of questions as it happens about the Natural History Museum but you understand that is only part of our remit. I think we would all like to take advantage of the accumulated expertise of the Museum to look at the broad issues, if we may, which we have looked at, and the state of systematic biology research. Although I think it would be fair to say you have been reasonably optimistic within the limits of the finances in which you are placed, nevertheless there is

no denying and we have had a lot of witnesses who have referred repeatedly in terms like the "malaise" in the particular subject. The fact is—as is represented to us and you have said—it is an unfashionable subject in universities and we even had evidence which suggests that it has become relatively less fashionable within schools. Have you got any general observations about that which could help us? Is it true in your experience?

(*Dr Chalmers*) I think it is true in the following ways; I think that in the university world particularly—which was the world I was in until 1987—systematics has almost dropped out of sight and in a large number of universities one sees biology departments closing down or closing down sections of their work and whole organism biology is suffering in comparison to molecular and cellular biology and particularly within that systematic biology is diminishing. I think that is a major cause for concern, frankly. Just going back to what I said earlier, a particular concern for us in the Museum because we are concerned as to where our graduates and post-graduates are going to come from. That is a cause of concern. The remedy is not simply one of money. One does need the money to support the systematic work. But it is in the end, I believe, a matter of attitude and of confidence in the subject. I repeat what I said earlier; I believe that university systematic biologists and those based in other research institutions around the country must clearly state what their priorities are and show what intellectually challenging and exciting problems they are addressing through their systematics. It must not be seen simply as a "Cinderella" subject or a service subject that has some sort of down-graded role. I think that it is profoundly important not just for the generation of taxonomic expertise in this country, it is also important for the general education of our graduates as they come through the universities. They ought to know about the diversity of life and the rationale upon which we recognise relationships and patterns within that diversity. It is part of a graduate biologist's general education, if you like. It should be there for that reason as well.

Lord Flowers

708. Chairman, is Dr Chalmers talking about priorities of individual research workers—I could not agree more if he is—or is he talking about possible national priorities for systematic biology?

(*Dr Chalmers*) I find it difficult there because I, of course, think and talk in terms of the Museum where we set institutional priorities within which individuals can work. I think it is more difficult to establish nationwide systematic biology priorities.

Chairman

709. One point which has been put to us, which may be helpful to you or otherwise, is because of our history, which has led to great collections that we have in Kew, Edinburgh and the Natural History Museum—and this point was made indeed by overseas witnesses who have written to us and others we shall see may say the same—the United Kingdom has not only a special responsibility but a special opportunity to play an international lead role in this

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subject. It often seems to me that if that could be stated in some way that we are playing this role, we would both have a strong argument for more funds and also it would be a kind of flag-ship that would carry forward with it an elevation of the spirit of systematists defined in the way we have talked about around this table, to include the molecular biology aspects and the computing aspects, the whole thing as a whole. Would you like to comment on that?

(*Dr Chalmers*) I think I would agree with those sentiments. We clearly do have a major international role that stems from the historical way in which we have amassed our collections and the expertise that has been there over centuries. This gives us a lead. In the end it is a question of persuading hearts and minds in our university departments particularly among those who make decisions about where to put their posts in biology departments. If you are head of a biology department is your next post that becomes free going to be a systematic biologist or a molecular biologist? It is a question of persuading heads of biology departments especially that the role of systematics in this country is as exciting and as broad-ranging as you have just outlined it.

710. Do you see a role for yourself here? Would it be possible for the Natural History Museum to, as I have just described and you have just confirmed, write to biology departments of universities and say this sort of thing? I ask you the question partly because we have got evidence from universities which is almost uniformly along the lines which have been mentioned, namely they are in a depressed state; they have lost posts; that the subject is no longer popular. It seems to me an intervention on your part of this kind, although strictly outside your terms of reference, would nevertheless signal to universities and institutions that significant people in the profession think this subject is important and that would be a significant help, I would have thought.

(*Dr Chalmers*) I think a letter on its own would be less effective than a letter and a certain initiative such as we have taken in the Museum. It was a very small one but I think that it is significant. When I came to the Museum I decided to set aside a certain sum of money each year for what we called the inter-disciplinary research fund. The purpose of that fund is to stimulate cooperative research with people outside the Museum—essentially people who are not themselves systematic biologists. We provide that expertise. We now have a number of joint projects with universities around the country of interest generally, what John would call “high risk”. They are pump-priming projects where we want to see if the work can be developed to a sufficient level that they would then attract research council funding. We are getting the interest of universities and institutions around the country in that area. I think that initiative along with a letter from me would be an effective way of proceeding.

Lord Porter of Luddenham

711. Perhaps this is a point, my Lord, where I might bring up the specific case of the Natural History Museum and Imperial College. Do you feel that there are great advantages in having teaching and research done by the same people?

(*Dr Chalmers*) That was not quite the question I was expecting but yes I do. I believe that they reinforce each other and if one can be taught as a student by someone who is an active researcher it is very good for the student and, vice versa, it does the researcher good.

712. And yet the major centre for systematic research in the country is not a teaching institution. And there is this obvious geographical possibility here which seems to me might attract – you have talked about systematics almost having dropped out of sight in the universities. You could have the strongest academic sector as well if there was some not just talking together but some joint appointments.

(*Dr Chalmers*) Let me tell you what we are doing there because I could not agree more. We have made one joint appointment, that was last year, in micropalaeontology between the geology department at Imperial College and ourselves. We had advanced to the stage of negotiating a senior appointment with them in molecular systematics, an appointment for which we have got some funding from a sponsor, an individual donation, which is very nice. I welcome the fact that we are right next door to Imperial College, they have a superb biology department and we are establishing a number of collaborative links with them and I would like to see some more. However, I do not want our relationship to become, as it were, exclusive. I do not want it to cut us off from relationships with other universities around the country or around the world.

713. Will those concentrate on molecular systematics because that is something which is new and not yet grown within the NHM, and Imperial might be where most of the NHM work is done?

(*Dr Chalmers*) Our next appointment we are looking for is a chair in molecular systematics which seems the most obvious thing to go for and to use the expertise of Imperial College, but I do not think you should underestimate what we have built up in our own molecular systematics laboratory which is beginning to suffer from overcrowding because we are now getting a number of grants and a number of people coming in doing excellent and exciting work.

714. Are those people undertaking a form of teaching?

(*Dr Chalmers*) They are not because they are not joint approval but the new chair, when in place, will do so. I should say, just for the record, at the moment this particular appointment requires a formal appointment by the University of London, it has been approved by Imperial College itself, that is what we are waiting for.

Chairman

715. Have you invited people to work on your collections who are in the departments of botany and zoology in universities?

(*Dr Chalmers*) Yes.

(*Mr Peake*) We have an enormous amount of collaboration on this which extends worldwide. We have every day in the Science Departments between 100 and 150 external visitors working, some of those are with us for two or three years. We also have

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[Continued]

[Chairman *contd.*]

embedded in the Museum research visitors from other organisations. We have a small team from MRC. We have close collaboration going on and we have people giving courses and seminars in the universities. We have in the past collaborated on joint London University courses on vertebrate morphology, but that has now changed because of variations in the courses in the University of London, not because of our lack of interest. The Museum funds students coming from the University of London with ecological taxonomic links with the Imperial building at the new research council centre.

(*Dr Chalmers*) The Centre of Population Biology at Imperial College.

(*Mr Peake*) There are a number of other initiatives and four or five other posts under discussions with other places in London and outside London, Joint appointments looking for the opportunity to interchange with our staff teaching and providing stimulus to students and to the cutting edge of people working in other disciplines.

716. In a sense it goes beyond the 20 miles range of London where the best students lie outside that range. We ought to inquire about how you get the teachers in those external areas who do not have a post, indeed you say that can be reflected in their teaching in those universities to which they go back? Have you any idea in your mind as to the geographical length as to where your people come from? Is it all over?

(*Dr Chalmers*) I think there was a list in the last annual report which showed it virtually contacted people coming into the Museum from British universities all over.

Lord Adrian

717. How do you tie up the picture you have just given us with the other statement that has been made that systematics is in a very poor way in the universities, because it sounds to me as if there are lots of people in universities coming to the Museum to work on systematics of one kind or another but if it is true there is no teaching in universities they are working in the universities but are not teaching, is that correct? I am puzzled.

(*Mr Peake*) I think these people come because they want to benefit from the expertise in the Museum. They are often people from other disciplines but we provide this opportunity to encourage them to respect and understand the range of opportunities opened up by systematics.

718. They are not just systematists?

(*Mr Peake*) Most of them are not but some of them are. I would not like to say at the moment what percentage from the UK are systematists but it is a comparatively small percentage.

Lord Adrian: It will be interesting to know what the figures are, but they may be difficult to determine.

Baroness Nicol

719. Could I go back to the research part of the questioning. We have not discovered from Dr Chalmers how the work of CITES is divided between the Museum and Kew and there are a number of questions there. I am sure you have prepared answers

for them. If we are running out of time perhaps they could be set out in writing but I would certainly like to have that, especially the division of work on DNA technology.

(*Dr Chalmers*) The division of responsibilities from the implementation of CITES is that which applies to the Morton Agreement as a whole, that is we will supply information on animals and also upon those plants for which we are responsible, which is algae, lichens and vascular plants in certain parts of the world, and Kew will deal with the rest of the vascular plants in the rest of the world. In so far as do we overlap with Kew on the molecular side of things, the answer is no, we do not do directly similar work. We have a good relationship with Kew and talk to them a lot, as we do with many other institutions. It would be stupid of us to overlap what they do and a patent waste of resources.

Earl of Cranbrook

720. The Director has made clear what benefits he has obtained from the Development Trust. Would he like to have the opportunity to say what benefits he looks forward to deriving from the Friends of the Natural History Museum now in formation?

(*Dr Chalmers*) Shall I give a little explanation about the Friends of the Natural History Museum?

Chairman

721. Yes, do. We are seeing Dr Barlow in October.

(*Dr Chalmers*) We have a members' organisation which has been a membership for people who purchase a season ticket merely and we give them certain benefits. The Friends is a particular initiative coming from Mr Barlow, who you are seeing later, which is aimed at the science of the Museum and they see themselves as supporters of the Museum's science. It is valuable for us to have a base for the support of people whom we feel we can rely upon for their backing when we are making our points to Government or to other organisations. I welcome the Friends in so far as they give us that backing. I have said to them quite clearly the Friends organisation in so far as it is part of their membership organisation which is part of the Development Trust, must subscribe to the objectives of the Development Trust, that is it cannot work independently of the Development Trust or have goals which are different from the Development Trust otherwise I can see problems arising.

722. In saying that, of course, you have been conscious, I am sure, of the natural fact that approach can quench the enthusiasm of people?

(*Mr Chalmers*) I think the goals of the Development Trust are very broad and one is not unduly restraining the Friends Organisation by saying we would like them to subscribe to the broad objectives of the Development Trust.

723. We have put a number of questions to you and if we were to ask all the questions we would encroach upon eternity. Do you have some points which you would like to mention now or like to send in a letter. Lord Adrian has one last question then I feel we must close.

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AND MR J LEGG

[Continued

Lord Adrian

724. I am sorry, but this has just occurred to me. Under question 13 the last few words say why was there such a fuss about the publication of the new regime in the Museum? What is your view as to what generated that protest?

(*Dr Chalmers*) I think there are a number of reasons. Clearly we took some managerial action which was very strong. We are a world-respected institution and any world-respected institution that generate the news that 100 posts are to be lost will quite naturally receive a large number of protests and letters of concern. Some of them are extremely cogently argued and others are the reverse because people do not like to see an institution like ours diminish in size. There is that. There is, I think, the fact that a museum is a certain kind of organisation

which is on the whole relatively quiet and self-contained in which change is a rare and not particularly welcome event. So I think we are the kind of organisation which is going to react more to change than let us say a major car manufacturer or let us say some large factory in the commercial world. I think there are a range of factors, quite frankly.

Chairman

725. Are there any other points you would like to make?

(*Dr Chalmers*) Not that I can think of straight away, Chairman. If I do could I write to you?

Chairman: Do any of my colleagues have any more questions. No? In that case, thank you very much for coming. We are very much obliged.

Supplementary Memorandum from Dr Chalmers on tenured, untenured, and externally funded research staff.

Tenured Staff

<i>Department</i>	<i>Curation</i>	<i>Clerical</i>	<i>Research</i>
Botany	15	3	22
Entomology	29	3	27
Mineralogy	15*	2½	9
Palaeontology	28	4	20
Zoology	34	3	27
Total:	121	15½	105

*This figure includes staff who provide facilities in the EM unit.

Untenured Staff

<i>Department</i>	<i>Curation</i>	<i>Research</i>
Botany	0	0
Entomology	0	6
Mineralogy	0	3
Palaeontology	2	1
Zoology	0	7
Total:	2	17

Externally Funded Staff including PhD Students

<i>Department</i>	<i>Curation</i>	<i>Research</i>
Botany	0	12
Entomology	0	9
Mineralogy	0	2
Palaeontology	1	15
Zoology	0	30
Total:	1	68

Total Staff in science departments

<i>Curation</i>	<i>Clerical</i>	<i>Research</i>	<i>Grand Total</i>
124	15½	190	329½

All these figures are as at 26th June 1991, and they do not include a number of appointees due to start work at the Museum shortly.

NEIL CHALMERS

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MINUTES OF EVIDENCE
TAKEN BEFORE

THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY
(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 25 June 1991

Professor C Stace

Professor J H Lawton

Ordered by The House of Lords to be printed 15th November 1990

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TUESDAY 25 JUNE 1991

Present:

Adrian, L.
Dainton, L. (Chairman)
Flowers, L.
Nicol, B.

Porter of Luddenham, L.
Selborne, E.
Walton of Detchant, L.

Memorandum by University of Leicester (Professor Smith and Professor Stace) printed by HMSO, H.L.
Paper 41, ISBN 010 404191 9

Examination of Witness

PROFESSOR C A STACE, Department of Botany, University of Leicester, called in and examined.

Chairman

726. Professor Stace, thank you for your memorandum, which has answered precisely the ten questions that were sent out, which we always find very helpful. You have, I think, also had a list of a number of questions directed to you and to Professor Lawton numbering in all 22, is that right?

(*Professor Stace*) Yes, my Lord Chairman.

727. We can begin in one of two ways. We can go straight to questions or, if you would prefer, you can make a general statement that might be background or interesting points in your evidence that you felt you wanted to emphasise.

A. I had not come prepared to make any general statement. I would be quite happy to answer the questions. I could make a general statement.

728. Please do if there are things that you would like to say?

A. Perhaps they might come out after the specific points, my Lord Chairman. The only general statement that I should like to make is that I am concerned that systematic biology is going in a spiral downwards and something should be done about it.

729. The problem there, I think, Professor Stace, is to know where is the best point to intervene to reverse the direction of motion of the spiral and turn it upwards, or at least stop it from moving downwards. The first question which perhaps bears on this is about the level of knowledge of students being materially less. That question is directed to the schools. Have you any experience of this? We have been told, for example—indeed, we have seen evidence—that the examining boards now make systematics optional, or some of them do, and in some cases because it is optional and because the staff of the schools are not very equipped to teach it, it is therefore deliberately avoided. Is that true?

A. That is very true, although to be honest, my Lord Chairman—and there is definitely a lack of knowledge of kiddies coming from school—I do not see that as a major problem. If people have it in them to be interested in systematic biology—and this is something that can be instilled in people very easily with inspired teaching—you can do this at university. I do not see it at all as a problem that they come with very little knowledge. There is a small nucleus of people who have this interest in their genes or by accident from an early age such as myself. It has been something in which I have been interested since certainly before I was ten. I do not know why; my parents were not—they encouraged me, but they

were not interested. There is still that same nucleus coming up to university with an interest in systematic biology from that angle. Others have not studied botany or systematic biology or any other form of biology until they come to university. I know a number of excellent systematists who were introduced to taxonomy at university and I do not know that they suffered from having no previous interest or knowledge or teaching at all.

730. That is very helpful because it does focus attention on the university sector. Do you have any figures, for example, on the decline in the number of people or courses in this subject in universities?

A. Not the comparable figures, my Lord Chairman, no, but the number of universities now that teach systematic biology is very small indeed in this country. I mentioned, I think, Oxford, Reading and Leicester. They are the only three I know of in advance. Twenty years ago virtually every biology department that considered itself able to cover biology more or less across the spectrum had a course that might have been called something else, but effectively it was systematics, taxonomy, classification, evolution, in various guises. There has therefore been an enormous reduction in the number of universities that teach it, my Lord Chairman.

731. Why has it been excluded from the schools of biology's teaching?

A. I think because it is not a subject that gets money, my Lord Chairman. To justify new appointments these days you have to show that the person in that appointment gets money for the department and therefore for the university. The Government is constantly asking universities, how much money is coming in from outside, what proportion of your income is externally generated; and taxonomists cannot help a lot in that field. I know two Fellows of the Royal Society who are taxonomists who never had a single research grant in the whole of their lives.

732. This is a double bind, is it not, Professor Stace, because of the nature of formula funding of universities through the Universities Funding Council where there is a factor for research, and that means that even without the transfer of funds that will take place from the Universities Funding Council to the Advisory Board for the Research Councils the latter Board is driving the way in which universities spend their money because of this attention that is paid to external research grants and the allocation of funds by the Universities Funding Council?

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PROFESSOR C A STACE

[Continued]

[Chairman contd.]

A. Yes, exactly, my Lord Chairman. Of course, it takes into account other things, such as publications and so forth.

733. But once those start to decline everything else follows?

A. The fund generation is a major part of it and it means, as you say, my Lord Chairman, that one suffers doubly.

734. Whereas in the old days, of course, the University Grants Committee used to have subject committees that made independent judgment. Those no longer exist?

A. That is right, my Lord Chairman.

Lord Adrian

735. The complaint that systematics was hard done by predates that arrangement for funding by a very considerable amount. While that may have contributed to the decline one feels that something was happening before that. We should not lose sight of the fact that systematics felt very hard done by for some many years before that. I wondered what interpretation to put on that?

A. It is the same reason, I think, my Lord Chairman. Whether the manifestation of it is that one is specifically asked to provide figures that say what percentage of one's income is externally generated or not, the fact is that systematic biology has not been seen for many years to be at the forefront of biology. It has not been seen as exciting; it has not been seen as topical or, in a single word, important.

736. Yes, I take that. Why do you think that that is the case? Do you think that all those things are true of systematics or do you think that they are untrue and a wrong perception?

A. They are true to a degree, I think. The reason is that systematics by its very nature is a subject that one can say (one can say this about every subject) is unique in a very special way in that it is a sort of basic subject. If you are dealing with X millions of organisms you need some sort of classification system to get them in perspective, to say, *that's* a rodent and *that's* a grass, and so on; you need something to start with. It is therefore a basic subject. However, the data that one uses in systematics are not any different from the data that are gathered from all other fields of biological science. The systematist uses all the data that are gathered by biochemists, molecular biologists, physiologists, and uses them in his classification. He uses those data to modify the basic classification that was set up many hundreds of years ago. In a different sense then taxonomy is the ultimate synthetic science because it utilises all data. What we look at is the possibility of having what one might call a perfect classification which truly represented the relationships of organisms. With that perfect classification if you used the name of a plant or the name of a family of animals those words would effectively be shorthand for everything that we know about that organism. If therefore you say *Triticum aestivum*, that name encapsulates everything that one knows about it: it encapsulates all the genetic information that that plant contains; it encapsulates all the literature that has been, one hopes, correctly pinned on that name,

Triticum aestivum. However, because of that nature of taxonomy it cannot be as urgent as other fields.

Lord Flowers

737. Your having described it as you just have, Professor Stace—and I am not a biologist, I say this having listened to you—it could perhaps be said that taxonomy is essentially a postgraduate discipline and there is no need to teach it at school or at undergraduate stage at all; indeed, you want people of mature judgment and broad knowledge who can bring in all these various fields?

A. My Lord Chairman, it depends what you mean by taxonomy in the sense that old fashioned taxonomy or systematic courses involved starting with the first group and saying: we are going to learn about the buttercup family today and then tomorrow we will learn about some other family. I do not think that that sort of teaching—it might exist in Dublin—exists anywhere in the British Isles. (I think that it does still exist in Dublin.) The sort of taxonomic courses with which I have always been involved teach the principle. You do of course have to instil enthusiasm in undergraduates otherwise they will not go into the postgraduate fields. They do have to know what taxonomy is about, what taxonomists get up to, what they are trying to do. You have to demonstrate to them that it is important, though not in the immediate term. It is not the case as it might be with molecular biology that we must give some money to this guy in such and such a university to do some research into getting genes from *this* organism to *that* one and it we do not someone will do it in America nine months from now and we will lose all the kudos for it. It is never as urgent as that. It is urgent in the sense, we must do it perhaps in the next five years. The trouble with the present grant system is largely that there is nothing like enough money to go round and when they have sorted out the alpha applications they say: what are the most urgent ones to be funded this time round. All the time it is the slightly less urgent—no less scientifically rigorous or valuable—ones that get pushed into the background every time.

Chairman

738. Could one not stand this argument on its head and say, for example, that the molecular biology work that identifies the material encoded in the gene that determines the properties by which you characterise plants or animals in your classification system would be valueless without the classification?

A. Indeed, my Lord Chairman.

739. So why do you not, as it were, latch on to the fashionable molecular biology and say you cannot do one without the other?

A. Well, we do. I deal in molecular biology. As I said earlier, the taxonomist has to utilise all the tools of biology and molecular biology is a tool of taxonomy as much as it is a tool of genetic engineering.

740. If I may just pursue this a little further, we agree on this particular point but someone clearly does not agree that it is important for the latter reason that it is necessary to molecular biology in this

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PROFESSOR C A STACE

[Continued]

[Chairman contd.]

field as well as molecular biology being valuable to it, so where does the fault lie? Is it within the grant awarding bodies? Are they not representative or not understanding?

A. There is a lot of different points there. I deal intimately all the time with molecular biologists because this is very strong at Leicester. My understanding of what they feel is that they do understand the importance of taxonomy and they do feel that taxonomy at universities and that it should be given research grants. My dealings with research grant committees is the same. But it does not have that urgency, and this is where it misses out. I do not think therefore it is the lack of understanding.

741. Understanding but not promise?

A. Yes, that is right. It is not the lack of understanding of one's colleagues or of the research grant giving bodies but the fact that when it comes to the nitty gritty of who will get the grant it will always go to one that is more urgently required.

742. You are in a sense advising us that it would be a wise thing to put the situation right, if it is true, to have some kind of affirmative action programme for systematics?

A. Whatever it takes is my attitude. If it is the only way, yes, I would very much like it to be the case that that was not necessary otherwise we are going to have every group of people saying, we want some affirmative action in this or that field. If that is the only way, well—and this is the sort of thing that the Australians have done. They have put a special amount of money into taxonomic funding.

Lord Walton of Detchant

743. I want to follow up the first points. There are two questions. First, you imply in the evidence that those grant applications that go to the research councils which are "urgent" get priority. Do you have factual evidence to suggest that the number of grant applications that are alpha graded but not funded is higher in taxonomy than in other disciplines?

A. I do not think the number is higher because the number of applications that come from taxonomists is small. The proportion is obviously higher but that is just a statistical quirk because nought out of one is a much lower proportion than one out of two. It is a difficult question to answer in a straight way therefore. The proportion of unfunded alpha applications is quite high in all fields. When you have a rather small number to start with the number of funded ones is inevitably nought in those fields. I hope that I have not made that too complicated.

744. In commending the attitude of the Australians in this regard where they have separated the funding of systematics research from other biological areas can you say how that could be done in this country? Are you suggesting some kind of earmarking of funds for taxonomic research?

A. That is exactly how it must have happened in Australia. This was told me by Dr Ryde of the Australian National University in Canberra. He is a zoologist and I do not know him at all well. The mechanism works, however, and it must be a form of earmarking of one sort or another.

Lord Flowers

745. Professor Stace, some of your fellow witnesses have tried to make a claim even that a special research council was required for systematics, which is going a bit far, in all conscience. There is an entire difference between setting up a permanent structure and saying: oh, this subject is more important than the recent behaviour of funding bodies towards it would suggest and we therefore need to raise the level of activity or standards and we set aside a sum of money for three years intended to back sensible proposals that will take it forward, after which it should have established itself sufficiently to look after itself in this way. That latter sort of thing, however, has been done many times in many subjects by all research councils?

A. Yes, I like you am against the general principle of setting up yet more permanent structures and mechanisms. The latter method seems to me far more sensible and fair.

Chairman

746. Are you aware of the initiatives that the National Science Foundation has taken in this field?

A. No, my Lord Chairman.

Lord Whaddon

747. I can appreciate what you say, that there has been a certain lack of urgency and glamour in taxonomy. Indeed, for many years it was something that the Victorians did. I should have thought that even in the last year or two there has been a dramatic change with the publicity given to the greenhouse effect and loss of genes from the gene pools and loss of varieties in developing countries. Do you find that this is fed through into attitude?

A. It has not fed through as far as research councils are concerned in making them decide that therefore they should give a bit of money. It is certainly fed through—as I have said before—to one's peers whether they are in molecular biology, in ecology or whatever they are in. The idea is there, I think, but the money is not; that is the problem.

Lord Porter of Luddenham

748. In your submission to us, Professor Stace, in paragraph (iii) you talk about the decline in plant taxonomy. Then you say there is significant research in only about three universities, Leicester, Oxford and Reading; and later in paragraph (ix) you say that that applies also to the same universities as far as undergraduate teaching is concerned. You are saying really, therefore, that there is no teaching in taxonomy or no activity in taxonomy at any universities in Britain except those three. I just want to confirm that, especially since we shall be seeing a professor who is not in one of those universities very shortly. I wonder whether he would agree with you on that?

A. My Lord Chairman, I am talking about plant taxonomy; that is all that I know about. There would of course be a correlation between active research interest and the undergraduate teaching so it is not surprising at the same universities. The sort of

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[Continued

[Lord Porter of Luddenham contd.]

universities that used to teach taxonomy such as Cambridge, Edinburgh, Newcastle, Manchester, Sheffield—I just think of those immediately—do not any longer.

749. I had in mind particularly Imperial College.

A. I think I know the only person at Imperial College who could possibly be called a plant taxonomist. He has retired this year. I do not know of any taxonomy course at Imperial College.

750. Or research?

A. The only person of whom I know, as I say, is Dr Dolby and has retired this year.

751. So it is plant taxonomy?

A. I am talking about that, yes.

752. If I may follow that up, my Lord Chairman, you go on to say quite rightly that to a large extent what work is done is done at the Royal Botanical Gardens at Kew and Edinburgh and at the Natural History Museum, and you say that this is undesirable for good reasons. Would you wish to see taxonomic teaching and research done at more universities, assuming the amount is the same, and less of it at these institutions?

A. That would be a very difficult choice—which arm shall I chop off? the sort of taxonomic work that is carried out at these institutions is different by and large from the sort that we would expect to be carried out in universities. Most of the institutions have specific projects concerning writing the flora of Malawi, a guide to the flies of the Amazon basin or whatever. There are exceptions to that, for example, the Jodrell Laboratory at Kew, which undertakes basic research in taxonomy. However, in the botany department at the Natural History Museum, for example, which I know very well, there is no or virtually no university type taxonomic research at all. It is what is called alpha taxonomy: it is producing floras and check lists and sorting out how many species there are in particular regions. There is no basic research into why these two species are different and what their biological relationships are and how easily they hybridise and whether the hybrids are fertile and is there a possibility of a gene flow between the two species. That sort of thing, as far as I am aware, is not carried out at the Natural History Museum or at Edinburgh. It is carried out to the extent of a very small amount at Kew. Even there, however, it does not relate to the European flora. It is almost entirely tropical work at Kew.

Chairman

753. Are you saying that from your university position you regard these national institutions as a source of material for research which is not fully exploited by those institutions and can only, as it were, be illuminated by work that is going on in the universities?

A. That would be a bit patronising, my Lord Chairman. I do not think that, no—I should not say it even if I did, but I do not think that. I think that they have a lot to offer, but I also think that we have a lot to offer. With regard to another question on the list—I am not sure whether to me or to Professor Lawson, my Lord Chairman—there should be much closer association between those places and the universities in my opinion. It is largely chance that

there are not. If one looks at the places in Europe where this goes on very successfully, Stockholm, Berlin, Vienna, Geneva, all those cities have a major university that indulges in taxonomic work and a major museum or other sort of institution. That is not true in Britain, only of Edinburgh. It might be true in London on the zoological side but it is not so on the botanical side.

Earl of Selborne

754. We have heard from a number of witnesses that taxonomy they would accept certainly is a fundamental part of the biological studies within their departments. Equally they would be suspicious if at least as a first degree there was not an equal insistence on molecular biology and the like. Some of our distinguished witnesses have gone on to say that although they would not describe themselves as taxonomists they have nevertheless given themselves grounding so far as is adequate and it has helped them keep up with modern taxonomy. Do you think that there is a danger therefore that if taxonomy is left perhaps within a ring fence with protected funds a rather insular approach to taxonomy might be encouraged?

A. I would hope not. It depends on the people using the funds. If they are what I would call good taxonomists they are the sort of people who talk every day to molecular biologists and so forth because, as I said earlier, they require the expertise of molecular biologists. We keep using molecular biology, but it is a buzz word, and that is why. You could substitute for that any other field of biology that you like. I do not see a danger of that at all at any institution which was what I would call a good taxonomically orientated institution. Taxonomists of necessity are the broadest minded people that there are. They have to be. They need the data from every other field. In reverse every day almost I get approached by ecologists or molecular biologists or plant physiologists saying: where do I find this plant, what sort of habitat requirements does it have, what is its chromosome number, what is its breeding behaviour with something else, do I have the name spelt rightly and do I have the author of that name put down correctly. They see the need for this. Taxonomists perhaps even more see the need for interacting with these other people. I do not think therefore that there is any danger at all—in the right hands, anyway—that taxonomy could become insular. It would be absolutely death to it if it did become insular.

Chairman

755. There seems to be a general view among good taxonomists that all you have said is correct. Why has the voice of the taxonomist not been heard loudly and clearly before on this issue in the public sense and representations made, for example, to research councils? After all, I can remember going back some years that it was the Advisory Board for the Research Councils which asked for taxonomy to be reviewed rather than the other way round.

A. I do not know the answer to that, my Lord Chairman. You are quite right, though: I do not

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[Continued]

[Chairman contd.]

think that we have shouted loud enough or in the right places.

756. If I may come back to the central point, and accept all your arguments for the time being, what do you think should now be done?

A. I should like to see more money given to the research councils.

757. As a whole?

A. That automatically would mean that the best taxonomic research would be funded. In an ideal world if enough money was given to the research councils taxonomy would then get funded. The Australian kind of situation seems Valhalla really to a taxonomist, and I am sure that it would to anyone else working in any other particular field if his field were taken out and effectively top slices or earmarked in a special way or however one would like to put it. That would seem to be a fallback mechanism. I should like to think that it would be done without those special sorts of arrangements. I am happy enough about the research councils and the way that they work to believe that it would. I know the people; I know the chairman of the plant sciences and microbiology sub-committee of the SERC at the moment, and I have talked to him quite a lot. He is at Cambridge. He realises that taxonomy needs funding. When it comes down to it, however, at the last round they had something like 35 applications and they were able to give only three grants.

758. Some people have stated also that in this particular field that not only ought we to do the top slicing that you have mentioned but there ought to be positive measures for enhancing the teaching. This takes us back to the original situation that teaching and research are so linked in their funding that it is difficult to reverse this, yet one has to break into the system somehow. The heads of the biological schools of research meet and have a committee, do they not?

A. Recently convened, my Lord Chairman, and I was on the executive committee.

759. Have they made representations to the universities about the decline in the number—if this is true, and we have been told that it is—of people who teach taxonomy in universities?

A. No, they have not. I would very much hope, and I have it in mind to do this, to initiate a procedure to get them to do that.

760. We have said, if it is true, because we have no numerical data on what you might call the time sequence of the total number of people teaching taxonomy at British universities over a period of, say, 20 years. Do you think that that kind of information would be ascertainable by direct questionnaire?

A. Yes, my Lord Chairman, I am sure that it would. I could even do it myself, I am certain of that. I am certain of the fact that it would show a marked decline.

761. In both zoology and botany?

A. I am not so certain about zoology, but I would be very surprised if not.

Lord Porter of Luddenham

762. I wonder whether you would agree, Professor Stace, that your reply as to what should be done is very hopeful but unrealistic. You say that there are only two or three alphas funded.

A. There were last year.

763. Even if you doubled the amount that goes to the research councils, which is what you are talking about, that would be only five or six?

A. Yes.

764. That is if things remain the same. The amount of funding to the research councils, as everybody agreed, has in fact gone up over the last years slightly in real terms, it has not declined, yet taxonomy funding has declined. Therefore, I do not quite see why you are so confident about the research councils and how they spend their money. They have spent less on taxonomy although they have had more. In any case, the chances across the board of taxonomy getting its share to the extent of the sort of increase for which you are asking is just pie in the sky. If you want to help taxonomy therefore is there nothing else that can be done besides asking for more money across the board?

A. I agree entirely with what you are saying. When I said that only three were funded this time, that was a rather special round, my Lord Chairman, where they had run out of money, perhaps due to mismanagement—I do not know. Although, as you say, the amount of money might well have gone up in the last few years, if you compare now with ten years ago in respect of the amount of money in real terms with the number of applications that were being made, I am quite sure that it would have gone down. It is a little like the National Health Service: the money goes up but the cost of the research goes up astronomically because new techniques come in and they cost a great deal more. If we take molecular biology, to allow a person to do molecular biology costs about £5,000 a year just in overheads, not even salary or equipment, that is, in little chemicals in tubes, as I am sure that you are well aware. If I may get back to the question, as I said, if in fact the situation cannot be remedied by more money to research councils, then reluctantly I think that one has to ask for some sort of special earmarking of funds for taxonomy along the lines of the Australian system or some other sort of scheme such as a special initiative of the research councils.

765. Which unfortunately most other branches of science would want as well, so you have to make a particular case for taxonomy, some change or some national needs?

A. Yes.

Lord Walton of Detchant

766. I should like to follow up the point that was made by the Lord Chairman in relation to teaching. Do you think that taxonomists themselves have to do something to put their house in order? I recall particularly my own son who read zoology in a university where you say taxonomy has been dropped, and practically the whole of the first year honours course he took was taxonomy. The feedback from the students was universally critical. They found it exceptionally dull and not inspiring.

A. Yes.

767. In medical education, with which I am very familiar, we are always talking about relevance. The question is whether there is a lot that needs to be done, apart from on the part of taxonomists, to make

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[Continued

[Lord Walton of Detchant contd.]

their teaching more exciting and relevant to modern science.

A. I could not agree with you more. I am quite sure that the case you mention is not isolated. I am certain that much systematics teaching in the past has been extremely tedious—the quickest way to turn people off. The idea of going through one group after another day after day is tedious in the extreme. I do not think that it can be remotely justified. Another question here is about quality: do we think that students are put off by poor quality this or that or the other. I think that the teaching is very often to blame. I do not know whether I should say this, but I have experienced difficulty in enthusing students. I think that it is entirely due to the way that it is taught. It should be taught as a relevant science, as you say quite rightly. In my opinion it should be taught as an exciting, dynamic science; it should be taught as something that is vital to the homo sapiens on this plant, and it should be taught as something that interacts very intimately with every other field of biology. Let me give just one example, my Lord Chairman, to illustrate this. I take students on a field course to Majorca each year. The idea of this is that they go to a place where they have never been before, and if they have been before they have not been doing the same sort of things as they do with me. The idea is to take them there where they know nothing about it. It could be Mars or Timbuktu; they know nothing about the area. At the end of the eight days what I want them to come back with is not a knowledge, “I can identify 500 species on Majorca”, but a knowledge if they were presented in the future with that sort of problem of how they would deal with it. They should be shown how you deal with problems like going to the jungle, going to wherever you like, and how do you start finding out about the plants and the animals there; what is the literature; how do you get over the problem of reading floras that are written in Spanish, and they soon learn that the terms are almost the same in Spanish, French, German and so on as they are in English; then, “How do I get over the problem of not having a full range of laboratory equipment with me?”; in what ways do the locals utilise the natural vegetation, how is it related to the agriculture of that region, and so on. It is not difficult to show the relevance of taxonomy. The person who plods through the groups—group one to the end—has been the cause of turning off a large number of students, I am sure of that.

Lord Adrian

768. If it is the case that the present state of taxonomy is to a large extent the result of poor teaching, what does that lead us to suppose? How are we going to achieve a better state if there are not any teachers and the ones that were teaching for the last 25 years were bad teachers?

A. I do not think that it is in large part due to that, but I do think that that is an element. I do not call that taxonomy; I call that systematic plodding through. I think that a large part of what was done in the past was not done by what I would call taxonomists; it was often done by a head of department looking round his staff and seeing someone somewhat unemployed in the teaching field

and saying, “You know something about algae” or some other obscure group (not that algae are obscure) of plants, “you should teach them this”. They do not have the integration themselves. It is not perhaps their main interest in life.

769. So even 25 years ago there were not very many real taxonomists in university departments?

A. There were not enough to go round every department. There were a lot more than there are now. I can think back 20, 25 years ago when I was a student and there must have been half a dozen heads of botany departments who were taxonomists. There is one now.

Chairman

770. Tending to bear out your point about inspired teaching, I should like to draw your attention to the fact that the animal kingdom course in Oxford, which is very systematic, is proving extremely popular at present, as I expect you may have heard, Professor Stace. I should like now, if I may, to turn to another aspect of our problem, which is that it has been held that this country is the custodian of very important collections in zoology and botany and that therefore we have as a consequence of our history the moral obligation to keep those in a good state and to do important work on them as part, as it were, of a global duty. Would you accept that, and do you think that it might be a means by which if we cannot afford to fund them we might look outside this country?

A. I agree entirely that it is a very important role that we must play. For historical reasons we do have the most important collections in the world by a long way. From what I know of Kew and Edinburgh and the Natural History Museum, which are the most important perhaps, they are adequately curated. They are not researched upon adequately. Everyone certainly will have heard of the Natural History Museum's problems recently and the way in which they have cut back in staff and in areas in which they have been doing work. However, I am quite confident that the level of curation is adequate to maintain the collections. The work is not being done on them. They do receive a large number of visitors from outside, my Lord Chairman. If funds could be found from abroad obviously it would be fine, but effectively they already are. For example, there are several institutions in the United States that fund research fellows to go and work in the Natural History Museum for three years. There are at least two Americans in the botany department of the NHM at the moment, one taking part in a major project of the Linnean Society that the society started. There is a flora project of China. This is a major collaboration between the Missouri Botanical Garden and the Government of China to write a flora of China's vast number of species of great importance. The Missouri Botanical Garden have actually appointed a person to spend full time in the Natural History Museum in London because of the importance of the collections in London. In a sense therefore I think that is already happening, but in a rather indirect and perhaps haphazard way.

771. We come to the point now where you said you might want to make a statement, Professor Stace, at

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[Continued]

[Chairman contd.]

the end. Is there anything that you would like to add to touch on points that we have not elicited from you?

A. No, I think all the major things that I wanted to say have been said, my Lord Chairman. I wanted to leave you the impression that I am really convinced that taxonomy is an exciting and dynamic subject and that it can be taught as one, but it is being starved of funds, and this leads to a spiral downwards. Taxonomists cannot get a lot of money because of the lack of urgency through which others see the subject. Therefore, new staff are not being appointed. There have been two new plant taxonomists, I think,

appointed in this country in the last ten years, and many have retired. Therefore, because not so many applications go to the research councils—and, my Lord Chairman, the membership of the research council is in fact a reflection of the fields in which grants are received—if rather few taxonomic proposals are received by these committees they will not graft on taxonomically oriented members. That is the nature of the downward spiral to which I was referring. That is something that I feel it is absolutely vital we should try to reverse.

Chairman] Professor Stace, thank you very much.

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Examination of Witness

PROFESSOR J H LAWTON, Director, NERC Centre for Population Biology, Imperial College, called in and examined.

Chairman

772. Professor Lawton, thank you for coming and thank you also for your written evidence that has addressed precisely the questions that we put in our letter to you. I wonder whether you would like to make any general observations before we begin or to emphasise particular points in that evidence. If so, the floor is yours.

(Professor Lawton) No, I do not think so, my Lord Chairman.

773. The first few questions relate to whether there is in effect a decline in interest and activity in taxonomy in the universities even in its broadest definition and, if so, why; should it be arrested and, if so, how? Do you have any comments on that?

A. My Lord Chairman, do you mean among undergraduates?

774. Among undergraduates and postgraduate work as well, of course.

A. If you define systematics as the traditional systematics, classification of the animal and plant kingdom and so on, yes, I think that there is. I think it is because students perceive it as being intellectually less exciting than a lot of the things that are happening in biology at the moment. Biology as a whole is a rapidly developing area. If you include in systematics, as I do, the use of modern molecular techniques then no, there is not. It is a very chicken and egg problem—or, rather, the curate's egg: it is good in parts. The good parts are those exciting bits that involve molecular biology and the bad parts are the more traditional areas, the framework of the classification of the plant and animal kingdom, which I do not think is very attractive to students.

775. Yet it has been represented to us and made perfectly plain that in a sense both the molecular biological aspects and the classical classificatory system are absolutely essential to each other; in fact, in so far as the genetic material defines the form and function of the organism it also defines the means of classification. Is this true?

A. Yes, my Lord Chairman. I do not believe that it is possible to be a successful molecular biologist unless you have some idea of the framework of the structure of the plant and animal kingdom and the microbial kingdom as well. Professor Sir Hans

Kornberg's lovely remark is that he knows only two kinds of organisms: one of them is *E. coli* and one of them is not! Hans is being modest; but that kind of knowledge in the hands of a less able person than Hans Kornberg is positively lethal.

776. One has to remember that he was once laboratory assistant in a chemistry department, was he not? You are arguing really for the fact then that what you want is teaching at the undergraduate level co-ordinated in a lively way with the teaching of molecular biology and again vice versa?

A. Yes.

777. The two are necessary to each other. Are there enough people who are able to do that?

A. I have thought about that and I honestly do not know how I would find out. I guess the answer is, possibly not. That is a question of what kind of lively teachers do we have and whether we do in fact have sufficient people, and I honestly do not know how I would find out.

778. As a corollary to this may I put the other point. Many people have said to us that the number of systematists who are teaching the subject in university has declined in the last 20 years. I take it that in so far as they were systematists who did not pay attention to the new developments you would not pretend to regret that decline?

A. No, I would not regret it.

779. On the other hand it does carry with it a diminishing size of the community and it means that the subject does get neglected in whatever form; it also means that their representation on research councils decreases, so it can be a downward spiral?

A. I think that that is exactly what has happened, my Lord Chairman. The problem is how you reverse it.

780. And how do you?

A. Taxonomy broadly defined has two different parts, in fact, at least two different parts, and I am sure that others must have said this to you, my Lord Chairman. There is a service part—how do I go about identifying this particular organism, be it a pest or whatever it is, which is not really doing research. This "service part" of the subject involves, for example, producing keys, which I think is an important skill, but it is not hypothesis based research. Then there is a whole group of problems

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[Continued

[Chairman contd.]

where taxonomy itself can be a hypothesis based science in which one seeks to understand the classification of a group or make predictions about what groups are related to each other and so on; or one seeks to use that kind of information in a broader scientific area. These two different parts require different solutions. The funding or the resources that one requires to produce service based taxonomy I think would have to be done in a different way from the funding that one would put into what I will call taxonomy that involves hypothesis testing. The latter I think could look after itself in competing for research grants if the questions are interesting, or if they are integrated with interesting questions from other areas of biology. There is no reason why that area should not compete quite freely. There is an extremely good example of that in a recent paper by Paul Harvey in *Nature*, about three weeks ago. In that paper, Harvey takes the modern classification of birds based on molecular techniques, and uses that information to ask a list of intriguing questions about rates of evolution, about different body sizes and so on. Now *that* sort of science will compete perfectly well with any other area of science. For that I think one simply has to allow that either NERC or SERC are prepared to fund research that is at the interface of taxonomy, evolution, molecular biology and so on, and that is not difficult. It is much, much more difficult to see how one provides adequately for what I will call the support side of the subject, the need to be able to classify particular organisms and to have the necessary keys in order to be able to do that. The funding for that in my view, my Lord Chairman, clearly is inadequate. How you provide adequately, I do not have any clear ideas. I have some semi-muddled ideas that other people must also have put to you already, but I do not have any clear ideas. That is a long answer to the question, my Lord Chairman, I am sorry, but I was thinking aloud.

781. It is a long partial answer because you have said that there is not an answer to the second part of the question. Some would argue that this is so much part of the basic nature of the subject that it has to be funded somehow.

A. Yes, I would agree, my Lord Chairman.

782. It used to be funded in part by the University Grants Committee and its successor, but now its successor is so linked to where research grants can be obtained in a sense that there is a marking of the grant for the research activity and that tends to drive the system in the opposite direction. Is that true?

A. If I was to put in for a grant to NERC or to SERC to say that I wished to produce a new key to larval moths in the United Kingdom (there is not one, out of interest: you cannot take a caterpillar at random and identify it without breeding it out to get a moth) it would not get funded; it would not be complete, given the limited funds that exist.

Chairman] Even though everyone would acknowledge its general utility?

Lord Flowers

783. But that means you have the wrong mix of people on the committee, do you not? If you had the committee populated entirely by taxonomists they would give first priority to such work?

A. Yes, but that will not be; it is a hypothetical question.

784. That is *the* question to which perhaps we have to address ourselves.

A. If there was to be a separate, adequate source of funding earmarked for such "service taxonomy", the problem would be much reduced. At the moment, my Lord Chairman, it falls also between NERC and SERC remits, which creates other problems. What I am groping towards and what I think is required is some separate source of funding for that kind of activity that would be peer reviewed, but it would have to be on its own terms and not in competition with, let us call it, hypothesis directed science.

Baroness Nicol

785. Professor Lawton, do you see any future in industrial money? In your submission you draw attention, for example, to the Freshwater Biological Association and the fact that there is a likelihood that research there is failing and the impact of that might not be good. Indeed, the Water Research Centre draws attention to that. Would it not be reasonable to suggest that the water industry should fund the kind of research that would pick up your needs in that particular area—and there must be others?

A. The answer to that, I think, is that they would say: it is a great idea, but why should we (industry) find it? Why would they want to do it? They might want to do it for altruistic reasons, and that would be nice if they did. More likely, they would have to have good commercial reasons for funding such work. One of the matters at which we are looking on the Royal Commission on Environmental Pollution at the moment, my Lord Chairman (for the water report) is the role of a classification of the state of British rivers using biological indicators. There is a series of reasons why that is a good idea and I will not go into those now, my Lord Chairman, unless you are interested. The point is that we already have the biology to satisfactorily classify rivers. Those taxa that we cannot adequately identify do not greatly distort the index of water quality at all, so the water industry would say: "We have all the taxonomy we need, thank you very much; we can produce a biological indicator of water quality, we already do that, and those groups that we cannot properly identify are not a problem for us". In such, they are unlikely to be interested in providing major funding. Let me expand slightly, my Lord Chairman. Water mites are a very prolific group. Yet we cannot identify water mites anywhere in Europe using a key because a key does not exist; and for some groups of midge (fly) larvae again there are no keys. But I do not see industry providing the funding to make good these gaps.

Lord Adrian

786. In regard to one of these keys, which are obviously desirable but perhaps do not exist at the present time, what is the kind of cost that is involved in producing them? When you go to a research council and say you want to produce a key of the moth and the larvae what are we thinking of in terms of money?

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[Continued]

[Lord Adrian contd.]

A. If we look at it in terms of scientist years, I have never done it, but I suspect that a key to moth caterpillars is a huge task.

787. Take something else.

A. Let us take the water mites. They are a small or relatively small group with a large number of species but not too well known. The FBA, what is now the Institute of Freshwater Ecology, have had at least one person working on watermite taxonomy for a long time. For a group like that you might be talking ten scientist years at least. (I do not know—Professor Claridge might correct me on that.) I think you are talking ten scientist years plus support costs. Now that is not a trivial sum of money, my Lord Chairman.

788. And support costs would be roughly—?

A. Take the scientist years and double them. To a good first approximation, work out your salary and double it, and that would be the kind of cost.

Baroness Nicol

789. What level of salary?

A. Call it £20,000 a year and double it, so it is £40,000 a year for ten years.

Lord Adrian] A substantial number of those scientists might already be supported in a university department, for instance, so it is a relatively small sum of money in terms of the grants from research councils.

Lord Porter of Luddenham

790. Where would it be done? We have been told, for example, regarding systematic plant taxonomy that research is going on at only three universities in the country?

A. That is right.

791. And teaching is going on in only three universities in the country. What would you advocate if there were a programme such as you have described that was funded? Would you advocate that we should try to build up the three that exist, that other universities should be encouraged so there is more of it or that it should be done in the Natural History Museum or at Kew or at Edinburgh?

A. The obvious strengths that we have in the United Kingdom—and they are considerable strengths—in taxonomy on a world scale clearly reside in Kew and in the Natural History Museum. They are the major international institutions. On the other hand, taxonomic research is not very complicated on space or equipment. It often requires no more than a microscope. If you get into molecular techniques, then that, of course, is more expensive, but there are many universities now which already have molecular genetics laboratories of reasonable quality. I am in fact a believer in centres of excellence, my Lord Chairman; I believe that it is not a good research strategy to scatter small sums of money round a large number of places. In the case of taxonomy, however, a really good, competent person interested in a particular group I think could probably do absolutely first-class research on his or her own, in a single university department and, if he or she is good, could be encouraged to do that. (Professor Claridge again would probably have

different views on that, and I do not know whether he would agree with that.)

Chairman] I should say, Professor Lawton, that Professor Claridge is not allowed to comment!

792. Perhaps I may follow that up, my Lord Chairman, with a specific question. The proximity of Imperial College to the Natural History Museum is an obvious thing to think about. From what both you and the previous witness, Professor Stace, have said it appears that it is very active in the field of taxonomy. What would you say about that, Professor Lawton? Would that be a suitable liaison?

A. Yes, it would! I am trying not to promote my own institution, my Lord Chairman, but Imperial College has a considerable strength in entomological work, for example. We are, in fact, about to make a joint appointment between the Natural History Museum and the college in molecular systematics, having recognised that there is a great deal of scope there for collaboration. That, I would hope, is the first of a number of joint initiatives between us. Therefore, we are trying to build up that centre of excellence and build up exactly what you are saying. The point that I was trying to make, however, is that I do believe that it is possible for a single scientist working on his or her own to do perfectly good taxonomic research in a university department. Too much central direction and too much attempt to create centres of excellence in this particular area of science I think is not necessary. I do not think one should discourage it—though indeed I would discourage it in certain areas of science, but this is one that I do not think I would.

Chairman

793. Perhaps we may turn our minds, as you have already mentioned it, to the problems of the Natural History Museum itself. First, there is the general question: this country has very large collections that are very important in an international sense. A number of questions arise here. One is, are we being good custodians or should we spend more money on those collections. Next, should the museums and botanic gardens be doing more research and, indeed, associated with that, can good curation take place without having active research in the institutions responsible for collections? How do you see those issues, Professor Lawton?

A. My Lord Chairman, I believe that the Natural History Museum is not at the moment adequately funded. If you look at the number of taxonomists that it has employed in the relatively recent past and the fact that it is still going down, I believe that in whole areas that are important it no longer has taxonomists. I know you must have had evidence from them and that they have already documented that before you. As a nation, because of our past, we happen also to be custodians of collections that are very valuable on a world scale: they are the equivalent of the Elgin Marbles or the other things that we have gathered from various parts of the empire. We do have a duty to a greater scientific community to look after those collections. We have a duty also, I think, to train taxonomists from the developing world where many of those collections have come from as part of the use of those

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[Continued]

[Chairman contd.]

collections. The question of where the resources should come from to do that, of course, is a problem. I doubt that it is possible effectively simply to curate material without actually using it to do research. If one treats it simply as a dead entity that is stored and not used I doubt that the material would be properly used—indeed, I am not sure that there would be any point in keeping it. Who is going to use it? You know that nobody is actually going to open the drawers and identify and use things within it. The whole thing becomes useless.

794. From what you said about its importance to the developing countries does this mean that it might be a sensible tactic, for example, to suggest to the ODA that one of the good forms of help to those developing countries might be to support students from those countries in investigations and helping in the conservation of those great collections?

A. Yes. Let us take a very specific example. In many parts of the humid tropics termites not only are interesting biologically but they are major pests. There are large numbers of species. To do anything with them, to control them, you have to know what you are dealing with. Somewhere like the Cameroons, with which I am involved at present, there are few or no local entomologists there who are able to identify termites. On the other hand, my Lord Chairman, there is no one employed in the Natural History Museum either who can identify termites now, but it would be wonderful to take one or more young Cameroonian biologists and train them in termite taxonomy. The ODA could and should do that. There is no one on the museum staff now to do that. Although Dr Bill Sands is still there he has retired, and is working as a consultant for approximately two more years, and then Bill will have gone. After Bill has gone there will be nobody.

795. And no one in the universities?

A. There are people who have experience of termites, Dr Tom Wood at NRI and Dr Michael Usher in Scotland who know something about termites, but they are not primarily termite taxonomists; they are termite biologists. I pick that as an example because there is a gap; there is a real need in terms of third world education and science, and the Natural History Museum has lost its expert.

796. It would be a natural thing for the ODA to support a post in the Natural History Museum in areas that were important to those countries that the ODA wanted to support?

A. I should think that there are a number of obvious groups within the insects, which is the group with which I am most familiar, where there would be a very strong case for training and the necessary support to be available in the United Kingdom.

797. If I may pick up on the remark that you made about the necessity for having people looking after the collections who were doing some research, we have received somewhat conflicting evidence on this. Some people say that it depends how you define curation: at a low level it is not necessary, at a high level it may be necessary. Do you think that it is absolutely essential for curators also to be researchers—or need they be scholars only?

A. You can have low level curation, there is no question about that. If you have research taxonomists—curators with a capital c—it is very

likely that they would require technical help, low level curation. Let me give two examples, my Lord Chairman. I have had cause to use both the Smithsonian and the Natural History Museum for research in which I required some insects to be identified, not from the United Kingdom, obviously, but from overseas. The Smithsonian did not have a taxonomic expert in the group that I wanted. It was hopeless, they could not help me to find the material that I wanted, they did not know where to start. The Natural History Museum with exactly the same material could find it for me in about 30 seconds and told me which drawer it was in. The person I asked had worked on it; he had not looked at it for about ten years, but he knew where it was.

798. There is a point here that we have not touched on, that in a sense those collections are like a mass of words without a dictionary and there is an opportunity to use modern high capacity, high speed computer techniques to put the house in order so that whether you go to the Smithsonian or to anywhere else you find it much easier. It was put to us by one witness that if you identified not the last individual group of species but just had a rough and ready method it would be much better than the present situation.

A. I think that that is absolutely true, my Lord Chairman. If there had been a computer database—and I knew what kind of insect it was, and I knew the family, and I knew where it was from—if we could have had a printout of the names of the drawers of all the holdings that they had from that geographic region and that kind of insect, it would have narrowed the search down enormously, but they did not have that information.

799. So that could be, as it were, the centrally inspired initiative in this field?

A. In this day and age I think it is crazy that there is not a central catalogue of the materials held in the Natural History Museum.

Lord Walton of Detchant

800. Perhaps I may follow up, my Lord Chairman. Do you see any prospect gradually over the years internationally agreed computerised database in this field?

A. Yes, my Lord Chairman. As it happens trying to produce an annotated list of our fellow travellers on the spaceship earth I think is at least as interesting as sequencing in the human genome, but that is a very personal view of what is worth doing and what is not.

801. At another point in your evidence, Professor Lawton, you talk about the need to train additional taxonomists. You referred to a national MSc course, and I wondered what you meant by that. Do you mean nationally funded and, if so, who would fund it and where would you put it?

A. Let us leave aside where we would put it, and I will come back to that if there is time. If we are going to try to strengthen and increase the number of taxonomists working in the United Kingdom and restore the position to that pertaining even a decade ago, then we are going to have to train some people. One way to do that would be to run an MSc course, not only in traditional taxonomic techniques, but in modern molecular techniques, in cladograms, in

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[Continued]

[Lord Walton of Detchant contd.]

computing and so forth. A number of such targeted MSc course in other biological subjects already exist. There is a conservation course at the University of London for example; there are at least three MSc course in ecology, funded by the research councils, so in principle there is no great problem in establishing an MSc course with a small number of studentships but about just three to six a year. If anybody else wanted to go on that course they could borrow the money or raise it, that is, do what they do at the moment. That, I think, would make a significant difference to the number of people training in taxonomy. It would not be very many people each year, but it would be a significant contribution, and it would attract overseas students whose fees would help to pay for the course. As to where it should be, I am a little reticent about pushing too hard, my Lord Chairman. It clearly ought to be associated with the United Kingdom's two major taxonomic centres of excellence, Kew and the Natural History Museum, associated also with the University of London. However, one could make a perfectly good case that it should be at another university associated with other museums that have taxonomic collections and so on.

Chairman

802. You are saying therefore in a sense that you accept the principle that there is a decline in the subject in terms of numbers and amount of work done and that in order to change that decline some kind of what has been called positive or affirmative action in this field has to be taken. Who should take it?

A. Since it cuts across AFRC, NERC and SERC, probably the Advisory Board for the Research Councils.

803. It has been suggested that they should set up a special group and do what the National Science Foundation has done.

A. Yes, ABRC—and I have just been asked to join a committee that NERC and AFRC are about to set up on the state of taxonomy in the United Kingdom. Professor John Krebs is chairing it, and we have a brief to start in August. That is all I know so far. There is at least that initiative under way, my Lord Chairman—probably spurred by yourself and your Committee's activities.

Earl of Selborne

804. Arising from that group to which you refer, in your written evidence you point to taxonomic groups that might have a practical importance—biological control, disease vectors, crop pest pollution and the like. Is there at the moment any effective organisation for what one might call a national strategy for determining taxonomic priorities? For example, who would determine which national collections were required for pollution indicators?

A. I do not think that there is

805. What I mean is: is there an oversight? There is such a diversity of work needed to be done in taxonomy.

A. It one takes the Natural History Museum's assessment of its research priorities, although forced

on it by a shrinking research base, this probably needed doing anyway. The museum was quite right, I think, to say: look, there is a limited number of species that we could describe and a limited amount of taxonomy that we could do—what are our research priorities? That was a good thing, irrespective of whether it was forced on them by a shrinking research base. The museum therefore has done that, and I think that other organisations would do it. If there was a research council or the equivalent of a research council to which people could apply for funding then there will be an element of self-selection in what one chose to work on anyway. You would have more chance of getting something funded not only if it was fundamentally interesting but also if it was also useful. I am not a great believer in centrally planned science: I do not think that centrally planned science works any better than centrally planned economies. In general I think that entrepreneurial science works as well as entrepreneurial economies. If you try to plan science too centrally you end up with a system that is like a centrally planned economy—and we know what happens with that!

806. Because taxonomy is making the case that it is underpinning the whole raft of the biological sciences, and—

A. Well, if you have an excellent proposal to do something very creative on the taxonomy of a totally useless group of organisms—useless in the sense of being of no practical use whatsoever—then you would want to fund it. On the other hand, if you wanted to do a rather more routine analysis you would have more chance of getting it funded if it was also related to a group that was practically useful. All scientists know that. That is the way we all work.

Lord Porter of Luddenham

807. My Lord Chairman, I wonder whether Professor Lawton might like to say a word taxonomy in his own place at Silwood Park. What I am feeling for is this. You have given many examples of your interaction with taxonomists at the Natural History Museum and so on. What was your own training in taxonomy, if I may ask? Are there any specialist taxonomists in the NERC unit at Silwood Park and, if not, are they managing nicely without having done courses? Do they pick it up as they go along?

A. I am not a taxonomist, my Lord Chairman. I am a whole organism biologist.

808. Do you find that you wish you were?

A. No, I do not, although I often wish that I was many things! I use taxonomy. I need to know the names of the organisms on which I work. I need to know properly what they are. I have never done any serious taxonomic research in the sense that I have never named an organism, I have never revised the classification of an organism and I have never sought to help a cladogram to understand the evolutionary relationships between organism, all of which I deem to be taxonomic research. I have, however, collaborated with people who are trained in all those areas.

809. At the Natural History Museum?

A. At the Natural History Museum, at the Smithsonian, and elsewhere.

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[Continued

[Lord Porter of Luddenham contd.]

810. My Lord Chairman, at the back of my mind is, what are the career possibilities for students who take taxonomy, if we take Professor Lawton's place as an example.

A. At Imperial College we have had in the past people who you would say were real taxonomists. Professor O W Richards was a very distinguished entomologist and did taxonomic research; so did Dr Nadia Waloff, to name but two. We do not at the moment because when those posts became vacant for whatever reason—I was not there then—they sought to fill them with areas of biology that they regarded as being more at the cutting edge of science, or did not fill them at all. If there was a general, modest increase in funding then I can see some very exciting possibilities to appoint what I call real taxonomists. I know who I would appoint: I would appoint a microbiological taxonomist—it is a very exciting, important area. If there was a modest increase in funding then I do see career opportunities in ODA, NRI, the museums and a small number of university departments, and, if people were good, and they would have to be extremely good, there would be posts, also, overseas.

Chairman

811. Professor Lawton, the gist of your evidence both written and spoken seems to suggest at least to me that the subject is at a curious crossroads: it is ripe for development because of the new techniques and it is extremely important that we have a special responsibility for all the collections; yet on the other hand the state of taxonomy both teaching and research within universities has declined over the years. It is odd, is it not, that the voice of the heads of botany and zoology departments does not seem to have been raised very loudly, it has not been much heard on this subject, not have they come forward with any solutions? Is there a real problem? Have I described the situation accurately? If the heads of botany and zoological departments were to come forward with such a proposal I cannot help thinking that it would be heard. Do you agree with that?

A. I agree with your summary of my views, my Lord Chairman. I do not know why the heads of botany, zoology and biology departments have not come forward. I have never actually involved in that particular forum. I do not know how effective a forum it is.

Lord Flowers

812. They are presumably responsible for the existence of the problem?

A. I guess that is right, but not collectively. I think that it has happened by benign neglect; I do not think it is deliberate. I also think that over the last two decades, particularly the last decade, if I had been head of a biology department with an eye to funding possibilities and having to keep my research income up, I know what I would have done.

Chairman

813. What would you have done?

A. I would probably have got rid of the taxonomists.

814. So you are saying that the problem is inherent in the structure of the grant awarding bodies?

A. Yes.

815. That is a very important point, I think.

A. Yes, it is, my Lord Chairman. I thought that was the position that we had come to here.

Chairman] This does mean to say, I think, that is the biologists are all of a mind on this subject now that should be said, should it not?

Lord Flowers

816. My Lord Chairman, if I may quote Lord Ashby from years and years ago, the research councils *are* the scientists and their committees are made of people like you, Professor Lawton, and heads of departments?

A. Yes, but you have to distinguish between the two areas of taxonomy that I talked about, the service area, the ability to identify organisms, and the research areas, using taxonomy as an active hypothesis based science. The latter has looked, and will look after itself. I have funding, other people get funding, that is all right. The problem is in the service area, the ability to identify organisms and develop keys, that is, the service area of taxonomy. It is there that I think that the real problems rest. In the Natural History Museum and I guess in Kew—though I am less familiar with the situation in Kew—there has been an overall reduction of funding in these areas that span the gap between service based taxonomy and research taxonomy, the development of cladistic techniques, the development and understanding of the patterns of evolution and so on. A lot of that research went on in places like the museums, and their level of funding has declined. Where do they turn to?

Chairman

817. Since 1987 they can turn to the research councils for help with research, but they also have to rely on the Office of Arts and Libraries for a degree of core funding to establish within themselves the well found laboratory or its equivalent in this particular field.

A. Yes, that is right. With very great respect, my Lord Chairman, on a committee with one taxonomist on and lots of molecular biologists you may argue as strongly as you like, but you often do not win.

Lord Flowers

818. May I just take Professor Lawton up on that, my Lord Chairman. It is easy to blame research councils for—

A. No, I was not blaming the research councils. I was simply saying that we have a funding system in place that has failed. How do you apportion that blame? I have not apportioned any blame; I have just said that that is what has happened.

819. But the decisions between applications are taken by scientists, most of them from the universities?

A. That is a very simplistic view, is it not? You have to ask first of all about the overall level of funding

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[Continued]

[Lord Flowers contd.]

and the apportionment of funding between physics, astronomy and what have you—matters decided at the highest level by ABRC. You then have to ask within research councils, the SERC for instance, about how one kind of grant would fair in competition with another. You know as well as I do the sort of discussions that go on in those meetings. It is not as simple as that.

Lord Porter of Luddenham

820. My Lord Chairman, I am confused. May I try to clarify this. I thought that you said the research is okay more or less and the research is funded by the research councils, so we are not talking about the research councils. You said that it is the systematics, the user—

A. The service end.

821. — that has to be funded. It is nearly all the NHM and that has to be funded by the Office of Arts and Libraries. I just want to get this quite clear. Are you saying that that is where the trouble is?

A. The fact that the Natural History Museum is funded by the Office of Arts and Libraries is, of course, most peculiar, because

822. Well, you see—I am sorry to interrupt—you talked of only one systematist on the committee. There you were talking about the research councils. There would be none at all, would there, on the

A. No, there may not be on the actual research councils.

Lord Walton of Detchant

823. But the implication surely is in a sense that you are suggesting the service taxonomist should be part of the support system, the overheads component rather than the research component, the very bit that the ABRC wants removed from the universities and the research councils. You are saying that it should be part of the well founded department? Is that not what you are effectively saying, Professor Lawton?

Chairman

824. Let us give Professor Lawton time to reply—there is a whole raft of questions now!

A. Let us just stand back and remind ourselves what I thought that I said. There is a continuum in systematics that goes from service taxonomy right the way through to evolutionary questions, the production of systematic relationships, trying to understand the rules of evolution. At the best end of understanding the rules of evolution, grants I think would compete fairly and easily, if they are good proposals, at SERC or at NERC or what have you. I have not seen the figures, and I do not know how well they compete, but there is no reason why they should not compete. There is then a continuum along which it gets progressively more and more difficult to find funding. Indeed, on the Natural Environment Research Council when I was on the terrestrial life-sciences committee we had several proposals that came forward that were basically to produce key groups. One particular one I remember was to produce a key to larval hoverflies. It was a good proposal of its kind, but compared with some of the more exciting stuff, and given the limited budget, it

was perfectly obvious that you were not going to persuade the majority of the committee to fund it. It is not a level playing field as far as that goes. Then you also have the problem of non-university research establishments—the Institute of Freshwater Ecology, the ITE, the NERC stable, the Natural History Museum, Kew—all of whom have had or currently do have one or more taxonomists or systematists on their staff, doing both service taxonomy and research taxonomy. It is therefore a very complicated mix of people and funding. The overall level of funding, I perceive, is not adequate to sustain even the modest requirements that we have across that broad area. I do not think that there is one single answer as to how you are going to fund that, my Lord Chairman. I do not have any strong views about where the extra resources should come from, except that in the end it has to be an overview provided either by a joint committee of NERC, AFRC and SERC, or ABRC or from yourself—there are a number of mechanisms—a number of wise heads that are going to look at the problem, and I guess that we will come up with a number of possible solutions. I do not, however, think that there is a solution; there will be several solutions.

Lord Porter of Luddenham

825. And the Office of Art and Libraries presumably?

A. Yes, although I think that is a bit of an odd way to fund science!

Lord Porter of Luddenham] I know, but it is where the funding comes from.

Chairman] It used not to be so, of course.

Lord Adrian

826. My Lord Chairman, it seems to me that if we have correctly identified the problem as being in the production of taxonomic keys—and I think you said that taxonomic research was better funded than the production of taxonomic keys—one could draw a parallel between the Natural History Museum and the other British museums where the production of scholarly catalogues of the contents of the museums is very much part of their activities and funded by the Office of Art and Libraries. If one thought of taxonomic keys as the equivalent of rather highly written up catalogues of particular groups of objects in the British Museum in Bloomsbury, that becomes a reason for the Office of Arts and Libraries funding it, not the research councils?

A. That is a very good analogy, I think, yes. It is one extreme end of the spectrum. Again, my Lord Chairman, I should not like to leave you with the impression that the only work that goes on at the Natural History Museum is the production of keys.

827. No, I entirely agree, but I think I was suggesting that the service taxonomy at the Natural History Museum one could argue was properly funded by the Office of Arts and Libraries along those lines whereas the taxonomic hypothetical research would be, as it can be, applied for to the research councils?

A. I do not want to leave you with the impression that key production is easy. It isn't. It requires deep

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[Continued]

[Lord Adrian contd.]

knowledge of a group to do it well. I suppose that you could write a totally arbitrary key to identify a bunch of randomly chosen organisms, but it probably wouldn't be very enlightening about their biology. As to the museum, if you were going to do it for a major group of organism you would probably want to revise the way people classify that group, establish relationships and so on, and that as I say, underpins the production of good, sensible keys.

828. That would be entirely parallel to the activity in, let us say, cataloguing Islamic brass lamps or something of that type?

A. Providing we are talking about it at that kind of scholarly level I should be very happy with that analogy, my Lord Chairman.

Lord Porter of Luddenham

829. Are you saying then, Professor Lawton, that if that were funded by the Office of Arts and Libraries the problem is almost solved? you have said that the research side can compete for grants in the research councils. Is there anything falling between the cracks?

Chairman

830. Professor Lawton, what you have been saying is extremely interesting to us. It seems, I think, that the subject is a very important, indeed, basic element I all biology with which we are concerned. It is also clear to us that you feel that there is a real problem here. You have mentioned not once but a couple of times that the mechanism of the operation of the research councils somehow lets a good deal of this work—to use your own words—slip through the cracks. Partly that is something in the normal fluctuations of what one might call the dynamics of any group of people, I think you would agree. But I am surprised in these circumstances—here I come back to my main point—if this is a generally held view in the biological community that they have not been articulate about it. It is clearly in their interests and in the interests of the country, of course, to have these problems highlighted with suggestions as to what could be done about the problem.

A. I have been thinking about that while I have been talking to you, my Lord Chairman. I guess it is attrition, which is what we are really talking about. It takes time to notice attrition. If it is a process of attrition, which I think it is, I guess that it is only about now, perhaps the last five years particularly, that people have become increasingly alarmed. I could turn the question round, my Lord Chairman, and ask: if it had not been a problem that people perceived as becoming particularly pressing I doubt that your Lordships would have found the time to look at it—somebody must have told you that it was an important problem?

831. The direction of the question, I think, is not in the way that you have suggested. This, I think, brings us appropriately to the end of this discussion unless, as I said at the beginning, there are some general remarks that you might wish to make as a result of the discussion?

A. My Lord Chairman, the only question that I thought you were going to ask me and have not, was

whether you thought taxonomy overall was proportionately more poorly funded than some big spending areas of science. If one thinks of astronomy, physics or what have you, in terms of the amount of money that is invested in those areas of big science, taxonomy is clearly the poor relation—whether correctly the poor relation is arguable. I thought that you might ask me that.

832. The reason that we have not done so is because it is very difficult to define the subject in ways that separate it clearly from any other activity for the one part. Secondly, it is very difficult to untangle some of the research grants to place them in that category or somewhere else.

A. The only think I would say to you, my Lord Chairman, on that is this. Let us take a really exciting question, which is, how many species do we share the planet with, and not just a list, but why is it that number, why is it a number of the order of ten million species and not 100 million or one million? That is the kind of question that is, I think, at least as interesting as sequencing the human genome. It is also a question in fact which, unlike others, is strictly time limited. If we do not answer it in the next two decades then we are not likely to be able to answer it. Science does not often have a sense of urgency. I happen to care passionately about the creatures that I share the planet with and I think that it is a time limited question. If we are going to do anything about conserving them and understanding diversity, we need to do it now.

Lord Adrian

833. Is it time limited? After all, geologists and paleontologists surely are telling us nowadays that there have been many previous catastrophes on this planet where a very high proportion of the species existing were destroyed, and the diversity occurred again?

A. Of course. We have a very small sample of that fossil record. We know roughly what the pattern has been like over evolutionary time and we can ask questions about what influenced the pattern. My question is related, but different, and concerns the end point of evolution: what is the currently extant number of species, plus or minus half an order of magnitude, and why is it that particular number? For example, is the number of species a randomly floating number, or is it constrained in some way? To what extent is it constrained, to what extent is it a product of historical accident and so on? These questions are intriguing questions.

834. Yes, I do not disagree, but—

A. If we are going to answer it with extant flora and fauna we had better start looking at it now, because most of it, whatever we do, is going to go in the next 50 years. Therefore, I think that it is a time limited question. Whether it matters if most species go extinct in terms of the function of the biosphere is an entirely separate question. It probably does not matter in terms of the overall function of the biosphere.

Chairman] Thank you very much for a very interesting morning, Professor Lawton.

MINUTES OF EVIDENCE
TAKEN BEFORE

THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 2 July 1991

Professor V Heywood, Dr C Patterson

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TUESDAY 2 JULY 1991

Present:

Adrian, L.
Butterworth, L.
Cranbrook, E.
Dainton, L. (Chairman)
Jellicoe, E.

Flowers, L.
Porter of Luddenham, L.
Taylor of Blackburn, L.

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Examination of witness

PROFESSOR VERNON HEYWOOD, Chief Scientist, International Union for the Conservation of Nature, called in and examined.

Chairman

836. Thank you very much, Professor Heywood, for coming. We have, of course, both your evidence sent in very much earlier and also your responses to the specific questions. I wonder whether you would like to make a general statement, nevertheless, before we begin or whether you would like to go straight into the list of questions which we have sent you and which you have had time to consider. It is entirely up to you whatever you think, with your greater knowledge, would be the most effective way of proceeding, although I would like to know one thing—and I am sure the Committee would—which is the precise status of the International Union for the Conservation of Nature, which you now work for, what its importance is and what is its particular bearing on our problem?

A. Thank you, my Lord Chairman. Perhaps I could begin simply by answering your question. The International Union for Conservation of Nature and Natural Resources, nowadays known as the World Conservation Union—it has changed its title recently—is, I suppose, a unique body in that it is neither governmental nor non-governmental. It is a union of about 650 organisations, over 60 state members, including the United Kingdom, and the remainder are non-governmental organisations. It was founded over 42 years ago and is, I think one can claim, the world's leading organisation devoted to conservation of natural resources and was responsible, among other things, for the World Conservation Strategy. In addition to its staff based in Switzerland with a number of outposts here and there, including my own office at Richmond, it runs a number of commissions, the most famous of which is the Species Survival Commission which Sir Peter Scott used to run, and has been largely responsible for the Red Data Books for rare and endangered plants and animals which are adopted worldwide, or at least the principles behind them are adopted worldwide, for categories of endangerment and threat which are used to categorise rare and endangered species. Also, it was responsible, and is responsible, for developing the protected area system and a lot of the methodology that went behind,* and it is currently an active partner with the World Resources Institute and the United Nations

Environmental Programme in developing a Biodiversity Conservation Strategy and Action Plan which is about to be launched in Europe in July under the sponsorship of the Linnean Society in London through a European Consultation. That is, I think, the largest and most integrated, or integrative in the sense that it brings in other organisations, biodiversity programme.

837. So you would say, or perhaps we should say on your behalf since you are too modest to claim it for yourself, that you are singularly well-placed, if you find the necessity, to undertake systematics research in relation to the whole of the global system of plants and animals? Is that claim too much for you?

A. I think I could claim, sir, perhaps to say that since I have had a substantial career in systematics and now am devoted, shall we say, to the other side of the table, conservation and resources, that I have perhaps a broader experience than many. There are many people, I am sure, who could talk with equal conviction, but I do, I suppose, know the feeling of most of my colleagues in the World Conservation Union in so far as they have a feeling on this subject.

838. You do seem to suggest, and I agree with you, from your written evidence that the subject is in decline, at least in certain areas, at the moment and, of course, we are asking particular questions to know what were the reasons for this decline. Would you like to tell us what you now think, if that is true, and if so, what should be done about it?

A. I think from my observation worldwide the subject of systematics and taxonomy in particular is in serious decline, curiously enough at a time when public demands for it are ever-increasing. There is a sort of paradox there. As I think I said in my submission, the reasons for this decline are the dual nature of the subject and the almost dichotomous trend that has developed in systematic biology over at least two centuries. The aim is, on the one hand, to be a practical science providing a service for people who need to know and handle that diversity in manageable chunks called species, genera and so on, and it is a purely practical need which we all depend on. We have to name or refer to organisms in some way and, most investigators would suggest, to try and find out where they came from and how they are related and so on, and the two do not, I believe, necessarily—and the history of the subject

*Note by the witness: Through its Commission on National Parks and Protected Areas.

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PROFESSOR VERNON HEYWOOD

[Continued]

[Chairman contd.]

demonstrates this—go together. The same person can do both and, indeed, it is a very common situation but they are not necessarily the same approach.

839. And as it would seem, there are fewer people studying it?

A. There are worldwide fewer people in the developed world studying it, I believe, but I do not have figures for this. I know that is true for the United Kingdom, as far as I can ascertain. It has virtually disappeared as a subject, for example, in France, but much earlier. The French not only got rid of the systematic biology very effectively as an academic discipline through the about CNRS 20 years ago but they got rid of botany as a subject as well and divided it into little pieces. They linked systematic botany with pharmacy because they thought historically that is where it belongs.

840. *Materia medica*?

A. *Materia medica*, pharmacology and so on. It is in decline in Germany, for example, and support in the United States, unfortunately, has declined, although there are obviously centres where it is flourishing. I spend a lot of my time in developing countries and there is an enormous development of interest there but the institutional support is very poor indeed. One of the problems we have to face, both as a profession and as a country, speaking as a United Kingdom citizen, is the disproportionate resources and whether anything could be done to remedy this. If I may pursue this point, I have just come back from a workshop held in Costa Rica at the National Institute of Biodiversity, which was devoted precisely to the question of tropical countries with enormously rich biotic resources managed and handled in terms of systematics and taxonomy, and part of the answer as I mention towards the end of my submission, is the use of what are called parataxonomists; in other words, not fully trained taxonomists. If you wish, I can explain that in more detail later when we get to it. The other is a feeling that has now developed quite strongly that perhaps there ought to be some transfer of resources from western countries to tropical countries so that most of the work identification can be effectively undertaken in the countries themselves. It is by no means an easy task. It is not just a matter of moving the resources over. There are all sorts of problems—the logistics and training and so on—but there is a very strong feeling developing that this must be the path ahead. That leaves a different role for major institutions in the United Kingdom and elsewhere.

841. We must concentrate on the United Kingdom. That is where our remit lies, of course, and yet we cannot escape our responsibility because we have these great collections which must be well-curated and the places for research as well.

A. That is true.

842. Do you think at a time when the opportunity is here in this country for systematics research to be combined with molecular biological research and also computerised data systems which allow the method of ordering the data in a useful way, and when the underdeveloped countries need this kind of service, which is the classificatory work, that we are

weak in in this country? Is it your judgment that we are weak and where does the cause of that weakness lie and how could it be improved? When you made your observation about some special funding, we would like to hear about it.

A. I do not think that one can say in general we are weak. I pointed to certain deficiencies in the United Kingdom system but that is not an overall statement that we are weak. We are indeed, I think one must accept, extremely strong in the facilities and in the staffing we have in systematic biology. We do have, after all, in London two major institutions within miles of each other, the Natural History Museum and the Royal Gardens at Kew.

843. May I interrupt there to say it was pointed out to us by those who gave evidence from the Natural History Museum that the staff had been reduced by 150 from a staff of 880. Is that not a serious problem—or were they overstaffed before?

A. It is not for me to talk about the structure of the Natural History Museum. I suspect there may have been some overstaffing in certain areas but that does not mean to say the same total complement could not be redeployed more effectively elsewhere. I doubt whether there is any institution that could not do with a certain amount of staff reorganisation. But what I am saying is that by making international comparisons the staffing of the Natural History Museum and the Royal Botanic Gardens, Kew, is—I hesitate to use the word “generous” because that might be misinterpreted—by international standards fairly impressive.

844. Why was there this great international outcry about the change in policy in the reduction of staffing at Kew?

A. Because the world had got used to these superb institutions having not only the facilities but sufficient staff to undertake all the programmes that they were engaged in. I suppose the question we are asking as to whether they were undertaken as efficiently as they might be is a totally separate issue.

Lord Flowers

845. Was it just a knee-jerk reaction on behalf of the international community?

A. I think automatically when one sees one of one's favourite institutions, one of one's models, being attacked one has a certain amount of knee-jerk reaction, though most of the comments were perfectly genuine anguish at the loss of activities in certain key groups.

846. Was there any truth in them at the end of the day?

A. I think it is too early to say what the effects will be. I, like all my colleagues interested in this field, would deplore any loss of staffing but I would have to go to the other side and say that I do not think one can necessarily justify indefinite increase in staffing which is often suggested, because I do not think that is something that any single country can justify. That is why I believe one has to look elsewhere for support, which is answering your second question. I think the scale of additional taxonomic work that needs to be undertaken if we are going to get to grips with some part at least—not all—of the biodiversity crisis is

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[Continued]

[Lord Flowers contd.]

completing part of the inventory, not all of it, describing more organisms. I would not advocate describing 30 million insects, if that is how many there are. I do not think it is feasible technologically or even justifiable. I may be slaughtered by my colleagues for saying that, but I disagree with Professor E O Wilson, for example, on this point. I think that is not realistic. But there is a need, and the demand is there from user organisations such as my own, for a much greater knowledge of biodiversity in certain groups and certain areas, and that I believe is beyond any reasonable institutional capacity of United Kingdom organisations. I think it needs special funding through the United Nations system or whatever source. I am not saying it could not be coped with in these institutions but I do not think they themselves should be expected to pay.

Chairman

847. Is that the global initiative to which you referred in your evidence?

A. Basically, yes.

Lord Porter of Luddenham

848. Professor Heywood, in summary it seems you have told us that this country is stronger than most of the other developed countries such as those in Europe like France and Germany.

A. It is in systematics. It is certainly stronger than France without any question. It is stronger than Germany and stronger than any other European country.

Chairman

849. What about the Netherlands? We had evidence which suggested the Netherlands is particularly well placed.

A. The Netherlands is going through a crisis in plant systematics at the moment because a lot of their effort, as you are probably aware, has been associated with Indonesia and the Flora Malaysiana project—one of their big projects—has come into serious difficulties in such a way that it will take 200 years to complete this project. There was a crisis meeting about it a couple of years ago.

Lord Porter of Luddenham

850. Following Lord Dainton's question, with all these hundreds of letters that we received from similar institutions in other countries, mainly in the developed countries, do you think they were saying that, all right, the United Kingdom is stronger but it should be for some special reason because it has the collections, or were they defending their subject irrespective? Why, if we are stronger than most of their own countries, did they take the trouble to write to us?

A. I think undoubtedly a combination of both. There is a tendency to defend one's subject, but we are stronger than most because of our history. We have developed, as I am sure many people will have relayed to you, enormous historical links with many parts of the world and are fortunate in having unrivalled collections both of material and of

libraries and archives and, therefore, there is under, say, the National Heritage Act an obligation for Kew to maintain these and the only way to maintain a collection is not to put it under wraps but actually to work on it. So we have this international obligation and we have not been averse, particularly in earlier years, to accepting this and being proud of it and developing it in such a way that, for example, we alone produce the "Index Kewensis" which is a world service, one of the world services Kew produces. I know previous Directors have tried to get other organisations in other countries to help defray some of the costs but, as you are well aware, when you start asking for money from other countries they are not so keen to help. In other words, we have produced these wonderful services and, therefore, any threat to them is seen with great dismay by other people.

Chairman

851. It has been suggested in evidence *a propos* your remarks that our collections are of great importance and the developing countries need information very much themselves, so that perhaps it would be a proper activity for the Overseas Development Authority to play a part both in helping the training of people from overseas in the collections and also training people to exploit and use the collections at Kew, Edinburgh and the Natural History Museum, and perhaps even giving some support to the research at those three institutions. What would your view be of that?

A. The relationship between the Overseas Development Administration and taxonomic institutions has been a slightly unfortunate one until recent years. It was due to advice it received, I am told, that it was a "forbidden" subject, that taxonomy was not to be permitted, within its remit, although I believe the situation has recently changed. I am all in favour of using the national institutions in the United Kingdom as the basis for training but one has to admit that they are not set up as training institutions and this is a problem they are all having to face at present. You will recall that early Reports on taxonomy made very clear statements that the responsibility for training taxonomists and systematists should be that of the universities, not the national institutions, and they are not funded in such a way as to allow for such training. This would put yet another burden on an already over-pressed staff.

852. Yet we have also been told—there seems to be no argument about this—there has been a decline in numbers of those who can teach systematics in the universities.

A. Yes.

853. So this is a downward spiral at the moment?

A. I think so.

854. How is it to be reversed?

A. I think this question of where the responsibility lies will have to be looked at again. I would suspect that a combination of both universities and national institutions will be the answer and there will be the involvement of the ODA in this. ODA certainly is interested. For example, I undertook a mission on behalf of the ODA to Bangladesh last year to advise

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[Continued]

[Chairman contd.]

on the establishment and construction of a national herbarium for that country; so there is commitment there and ODA may eventually fund this building costing half a million pounds plus a training programme which I recommended. So, yes, I obviously do agree with such an approach.

855. It has also been suggested that, given that the national collections are where they are and given that the universities do the training, as you pointed out, there should be many more linkages of a working kind between the national institutions and the universities, and you made it clear in your own evidence that you had built that up when you were at Reading?

A. Yes.

856. Do you think that is still your view and it could be extended much further?

A. It is still very much my view but my concern is that it requires perhaps much clearer guidelines to be laid down by the national institutions. The obligations on both sides need to be tightened up because it is very easy, for example, to give academic titles to members of other institutions and find they never turn up and do anything for you. So I think one has to devise much more carefully thought-out, perhaps, memoranda of understanding so that the obligations on both sides are laid down, otherwise there is a great likelihood of not a great deal happening.

Earl of Cranbrook

857. In this context, I think it is appropriate to ask Professor Heywood to expand a little on the European Science Foundation Taxonomic and Biosystematic Documentation System—he mentioned specifically Reading University—of which he is Head. How does this fit into the role of national/international applications networking that you have been discussing?

A. The European Science Foundation Documentation System, ESFEDS, was developed as a result of an investigation put in hand by the European Science Foundation into the state of taxonomy to produce a report under the authorship of Professor Clarke and myself, called "Taxonomy in Europe", which gave a report on the state of taxonomy throughout Europe and made a number of recommendations, some of which have been acted upon, some of which have not. One of the proposals was to set up a European Documentation System that would take another project which I have also been involved in, I am afraid to say, the Flora Europea project, one stage further by transferring the information into a database so that one could more readily keep the information updated between publications—an information system, in other words—and the outline of this was developing. Due to financial reasons, largely due to withdrawal of German funding, for reasons we never found out, we ran short of money before the project was fully completed. I am glad to say that the system is now up and running again and it has been linked with the Natural History Museum in recent years. It is also installed in Missouri Botanical Garden and it is almost certainly going to form one of the bases for a

large new initiative in European systematics—plant systematics, I hasten to say, that is being hatched—I think that is the word—at the present day, linking in a whole lot of different organisations such as Mediterranean Checklist, which is a new computerised organisation dealing with the whole Mediterranean Basin plant-wise, and other initiatives of a similar nature, and ESFEDS will form one of the computerised elements from which a whole series of initiatives and structures will develop.

858. You have said it is for keeping up with events between publications. Is it an assemblage basically of specialised, unpublished data or a giant abstracting system?

A. It is a structure that will allow information to be included in it. It is a framework to which one can add all classes of information, including fields that are not normally systematically recorded, such as information on biochemistry, phytochemistry, cytology and other more modern approaches, so that that kind of information can be systematically assembled against a taxonomic framework and made available in a series of different kinds of outputs other than traditional floras. The project was to devise a structure, not to implement it. Obviously implementation is something that would go on for ever.

Chairman

859. Coming back to implementation in this country, the weight of the evidence is that all is not well in the state of taxonomic Denmark in this country in teaching at postgraduate level and at undergraduate level in universities and the shortage distorts their linkages with the museums and gardens, and also the feeling that the research councils perhaps have put taxonomy on the back burner for some years. That seems to be the general view and there is a sense in your written evidence that you tend to agree with that. What suggestion would you have to make as to how that might be remedied?

A. My Lord Chairman, I think there is no very simple solution to this because I think we are dealing with an analysis of the different elements of the subject, as I tried to say earlier. I believe systematic biology covers a number of different approaches and I think we have to be very clear indeed which of the approaches and, indeed, which of the aims we are trying to address, which of the problems, which of the gaps. Are we trying, for example, to meet the biodiversity crisis by increasing the British effort in this, in which case one would go along one particular road? Are we trying to re-establish our pre-eminence in systematics as an academic subject in our universities and other institutions, a pre-eminence which once we held and I think almost certainly, I would claim has now moved to the United States? That would go along a different route, but you cannot plan a solution to this by just having a sort of overall approach saying, "Here are more resources." I think one has to identify the very clear targets of what it is one is going to go for, and if one goes for the first, which is increasing the amount of what we call basic systematic research, strategic research, by increasing the number and rate at which we are undertaking inventories and the number of floristic

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[Continued]

[Chairman contd.]

and faunistic publications we are producing so that we know what we are handling, I think we cannot do this in isolation; it has to be done in close association with tropical countries because that is where the big problems come. We are not facing in this country a problem about British flora or fauna, although there may be a few invertebrate groups where more research could usefully be put in. That is not the problem. We have enormous resources and a tiny biological base here, so I think one has to look at this in the light of what we are trying to do as part of our overseas effort. That again is where I believe with a combination of resource transfer, technology transfer, training and so on; that is one route. A more academic route I think could be quite readily solved and that is by the research councils agreeing perhaps to earmark money as they did at one stage for archaeology, which got into a rather similar situation. You may recall, my Lord Chairman, that when the ABRC report on taxonomy was issued some years ago the research councils passed it from hand to hand and none of them would accept responsibility. SERC said specifically it was not their habit to earmark funds for this sort of purpose, not even earmark studentships, which was not, shall we say, exactly a correct statement, and effectively nothing happened. There was no real effect from the report.

860. You yourself in your evidence mentioned the need for a national plan. With whom do you think the responsibility should lie? You have just said the ABRC but would not one include the Universities Funding Council or Polytechnics and Colleges Funding Council, except for the fact that there is no conversation between the funding councils and the ABRC at the moment?

A. Yes, my Lord Chairman, ideally one would, and I think I was anticipating that question. I have made a list of the bodies and that would include the ABRC certainly.

861. But somebody has to take the lead, have they not, and be the prime mover in getting an examination of the problems and seeing whether there are solutions which can be found?

A. I suppose one could prevail upon the Royal Society, although it has no great strengths in taxonomy, to take this role or to supervise such a committee. An alternative would be the Department of Education and Science, which does have very close links.

862. But it does have very close links. You are going down a slippery slope very fast.

A. I reiterate, it does have very important implications in terms of other countries, so I suspect you would have to get involved with the other departments, Environment, Overseas Development Administration and so on. I believe that that ought to be done.

Lord Porter of Luddenham

863. This is no doubt a point to raise with reference to what you say on page 1 here, which I wanted to ask you about. You refer to the low rating in academic circles of the subject and then more specifically say there is little prospect of taxonomist being elected to

the Royal Society, irrespective of his or her personal merits or achievements. Earlier you were telling us one of the products of the subject is the practical service that it gives and you referred to curiosity-driven research. I think you would agree it is on the latter that any appointments to the Fellowship would depend. As you know, election to Fellowship would be for original discoveries which are additions to natural knowledge. I quite agree with you that there are very few taxonomists there—this is a vicious circle—but if I asked would you be able to name a number of obvious cases who have made original contributions? I get the impression from what you have been saying that most of the work is in the more practical listing and very important services which taxonomists give. How many—could I put it that way?—taxonomists and systematists would you say there are in the country who have made original discoveries of the kind which would compare and compete with those in the other subjects when the Royal Society are deciding their difficult task between candidates?

A. Without mentioning names, of course, and excluding my own interests in the subject, I would say at least six without any hesitation. I would go before any Royal Society Committee and justify absolutely their claims to election to the Fellowship.

864. Might I just follow it up very briefly without mentioning names? Could you give some idea of the areas that you have in mind, the sort of discoveries in taxonomy which you have in mind?

A. Yes. One has to be careful, otherwise one does tend to identify people, but in areas which have been very prominent in recent years such as, for example, numerical systematics, applied taxonomy and genetic resources, to mention but two.

865. In numerical systematics what would be the original discovery you would bring forward, if you can do that again without naming names?

A. The virtual invention of a whole new methodology and a whole set of principles, theories, techniques and protocols—the lot, a complete corpus. They have invented virtually a new subject or been one of the leaders in developing a new subject. I must not pursue this, my Lord Chairman, because I am getting too near to identifying them.

Chairman

866. I think we must release you from those embarrassing questions and come back, if we may, to the problem of the next generation, the harvest from the seedcorn of the present, which does not seem to exist, partly because of lack of studentships, partly because fewer students want to come forward in this particular field, as I understand it, and partly because at the end of the day we have been told the career possibilities are reduced. Have you any views on those points?

A. Yes. I think, my Lord Chairman, the difficulty is that the number of well-founded centres in the United Kingdom where one can undertake high quality taxonomic research (which as I think I mentioned in my evidence requires a wide range of facilities) is very small, as is the number of staff who have built up such facilities and who have access to

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[Continued

[Chairman contd.]

research grants. It has become a vicious circle. I think you are well aware of the fact that SERC provides about one grant in systematic biology for the whole field out of every round, or something like that—it may be every other year. I did see the figures recently.

867. We have been told class alpha 3 is not often funded.

A. The chances for staff members at lectureship, readership, professorship level of getting funded, except for the more applied side in areas such as the field I work in myself, are very limited and it is very difficult to have an active research group with, say, research fellows and facilities operating that. I think this is what is causing a lot of people to be reluctant to go into this field unless they are so-called naturalists who will always appear, who do it for the sheer love of natural history. There is a steady stream of them but they do not necessarily end up by doing a great deal for the academic ranking of the subject. In fact, they are often looked upon as curiosities. So I think, although it sounds a facile solution, there needs to be some conspicuous effort to try and re-establish the subject in one or two centres. I know there are risks in this procedure, but it might at least get the ball moving. At the moment I see it just going into very serious decline indeed.

868. Returning to research in the national institutions you yourself, of course, being a trustee of Kew—or were until recently—will know a great deal about how the Natural History Museum has changed since 1987 in the way in which it can get funds from Research Councils now which was not possible in the past. The point which has been raised with us is the question as to whether the Office of Arts and Libraries understands the need, as a partner in what is a dual support system, for maintaining the well-found laboratory (your own phrase) in the Natural History Museum itself, or whether there is not a danger there in the trustees not having enough resources to maintain those facilities. What is your view of that?

A. My Lord Chairman, I am quite sure that the difficulty that so many people experience in understanding what systematics is about must be reflected in that area as well, so it is not reasonable, I suppose, to expect the Office of Arts and Libraries to understand what it is they have on their hands. I am sure there is no full appreciation of these multiple obligations that running the Natural History Museum has. They must, I presume, also feel under pressure from other bodies that they fund and there is, of course, the difficulty that a large part of the collection, as we have said on many occasions, does not have any direct or apparent relevance to the well-being of this country. They are collections of plants and animals and insects stored in acres of cupboards, dead and unattractive on the whole, and are the raw material for scientists working away on the fauna and flora of foreign lands. This must be a very difficult thing to justify, sitting on such a body, to one's colleagues. I imagine that is part of the difficulty. It is not a self-evident good for the country. I am not saying it is not—I am just saying it is not a self-evident one. That I believe is part of the weakness.

869. That is a description of the situation. What should be done about it? I should tell you we have three former trustees of the Museum sitting round the table.

A. I believe one ought to change the source of funding.

870. Do you?

A. Yes.

871. To what?

A. I am not sure that the answer is not in this national structure or national body that I suggest ought to be set up. I believe that is probably the answer.

872. But there are so many agencies in that particular body. One asks who is to provide the funding to them. Some of them are not, in fact, funding agencies that you mentioned. They sound more like a parliament.

A. Part of it could come, I imagine, from Government, as it does at the moment. Which agency of Government is a matter for the various ministers and the Treasury to fight about.

873. But how would you advise that?

A. By setting up, as I say, a body with specific responsibility for becoming fully informed as to the needs and setting targets and then advising them on how these targets could be met financially.

874. But answerable to whom? Would the ABRC set it up?

A. Answerable to Parliament, I imagine, eventually.

Earl of Cranbrook

875. Could I ask one simple question apropos these very large national collections which are curated by Kew or the Natural History Museum. As you pointed out, these were collected over many years. To what extent in your own field of botanical systematics is a very large collection of dried plants, some of them of great antiquity, really useful and to what extent is it a monument to be preserved?

A. Most of them, my Lord, I would say are of use but there is a certain amount of dross in collections and the sheer labour of getting rid of that dross is not worth the effort. So I would suggest that 95 per cent of the material is valuable. One could not say which without going through it all. There are obviously collections that cannot be localised properly but most of the material—unfortunately, it is the nature of the stuff—cannot be dispensed with. Often it is of historical value because of the association with naming.

876. It is not of any particular importance in new systematic techniques?

A. The day may come when one can extract DNA from herbarium material. I think that is round the corner, and so potentially, yes. It is extremely expensive and laborious and not a routine approach but certainly that will come. So I do not think one can dismiss such material, however unattractive it may be. It is the basic raw material of systematics, I would think. The raw material is in the field but you cannot bring the field into a museum and so you have to put it into such an unattractive state.

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[Continued]

Chairman

877. One final question, if we may, Professor Heywood. Many of us, I think, have felt from the evidence we have received that paradoxically the connection between genetic material and the form and function of the plant or animal now possibly represents a splendid opportunity, particularly when one is aided by computerised storage of data, for an advance in this general field which is being held back at the moment, according to all the evidence, by the lack of development on the pure classificatory side, and these three elements are essential to our knowledge. Do you think that is generally true and would that accord with your assessment of the position?

A. I believe that despite two active centuries of research into systematics we are nowhere near agreement on what are the appropriate methodologies for handling taxonomic information. Any survey of the literature will show this. I do not believe there is any other subject that agonises so much about how it should be prosecuting its own field as in systematics. It does concern me. I am not sure that I know the answer to it and I think it is a fact, and it is one that, if I may say so, is partly responsible, as I did suggest, for this difficulty that it has got itself into.

878. It sounds rather despairing to me, but taxonomists have been and always will be in a state of despair that the subject is not advancing as it should be. Is that unfair?

A. No, I do not think it is quite as bad as that. I despair in the sense, my Lord Chairman, that I have

watched through the whole of my professional career technique after technique come forward and be debated and always people hoping it will provide us with the answer. I do not think there *is* an answer which is probably the reason for this, but the basic fact is that we are only on the brink of enormous advances in cognitive psychology, in neuro-computers, which I believe may transform, in association with other techniques, the way in which we approach classification in the future. Maybe it is around the corner or maybe it is yet another panacea. I doubt I shall live long enough to have the answer to that.

879. We had better stop trying to peer round corners. May I thank you very much for the evidence you have given in writing and orally and ask one final question: is there anything we have not touched on that you would like to bring to our attention? If so, you can either do it now or, if you wish, send in written evidence.

A. If I may, my Lord, I would like to send in some information to you for your consideration on the field of parataxonomy.

880. Yes, that is a specific question.

A. I had the privilege of visiting a centre where this was developing a few weeks ago and I would like to communicate something.

881. Yes, indeed. Would you send it to the Clerk?

A. Yes, indeed.

Chairman] Thank you very much.

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Examination of witness

DR COLIN PATTERSON, Natural History Museum, called in and examined.

Chairman

882. Good morning, Dr Patterson. You heard what I said to Professor Heywood earlier and I do not think it is, therefore, necessary to repeat it, except to say the invitation is for you to make a statement, if you would like to do so, or go straight to the questions. How would you like to proceed?

A. Thank you. I think it is worth taking a moment to say that I am a palaeontologist in the Natural History Museum. I have been employed there for almost 30 years. My specialist field is fossil fishes, which means I also have to have a wide knowledge of recent fishes. I am also interested in, and have worked on, the theory of systematics, particularly in the introduction of cladistics, and through that I have gone into molecular systematics. I have wide experience of the American Museum of Natural History in New York and some experience of the other major American museums, but because of that background, my answers are bound to be slanted towards palaeontology and towards museums. I think that is all I need to say.

883. Thank you. You did hear what I said earlier and particularly this question: is there an opportunity which we are denied from exploiting because of the state of systematics in this country,

both with regard to people and institutions which are capable of training people and research which needs to be done and cannot be done for lack of resources?

A. That is a very complicated question, my Lord.

884. The question is there; I did not invent it. The problem is there.

A. If we see this in terms of, first of all, opportunities, the opportunities are there in the national collections. We immediately get into problems of funding and I saw in the written submission from the Royal Society to this Committee the point that full exploitation of the research opportunities in systematics in this country would seriously distort the overall balance of biological research in the United Kingdom. I took that distortion to refer to funding and to mean that increased funding for systematics would draw money away from other disciplines. I took it to mean that the Royal Society committee members, being wise in the ways of the world, saw the pot as being of a fixed size and that increased funding for systematics would necessarily draw money away from other disciplines. One of the questions put to me concerned the idea of a new funding body and I would think that a new funding body would have very little chance of success if it were true that the pot is of finite size and if it was

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DR COLIN PATTERSON

[Continued]

[Chairman contd.]

funded by drawing money from elsewhere. If such a body came with funds of its own, I would be in favour of it. But I think it is more likely that we should succeed by reorganising the present funding system, particularly in NERC. I think the issue here is not really concerned with the lowered status of systematics. I think it is to do with the quality of assessment and the expectations of the community of systematists. I cannot help thinking of the system in America where in NSF there is a unit for systematic biology. It is headed by a systematic biologist who is seconded from a university or museum for five years and is guided by a panel of professional systematists appointed for, I think, three years. The result of that system is that when grant proposals come in the expert knowledge is there to choose referees and assess the quality of the proposals and of the referees' reports. In this country in NERC things are very different. The split is between terrestrial and aquatic biology, which is patently entirely artificial. The panels in those subjects are completely dominated by people with interests in areas other than systematics and I think in just the same way the Royal Society group which reported to this Committee contained no systematists and so, perhaps naturally, they saw this Committee as a potential threat to funding for their own disciplines—things like genetics, ecology, physiology and behaviour. I think we all know that half the battle in getting funding from Research Councils is in having the right people on the committee. I think one fact that needs explaining is that I receive roughly five times as many proposals to referee from NSF in America as I do from NERC in this country; yet I am on the doorstep of NERC and have nothing to do with American funding. Something has gone wrong at that level and might quite readily be remedied by some reorganisation within NERC.

885. Are you really saying the state of the subject has so declined that it is not getting representation on the decision-making bodies and, therefore, the position is irreversible without tampering with the present mechanisms and that you would like us to borrow the National Science Foundation pattern and the analogue for that is for the Advisory Board of Research Councils to do something which goes across research council boundaries and identifies systematics for NERC, AFRC, SERC and MRC?

A. I believe so. The decline, I think, as Professor Heywood says, is almost permanent in the universities. It is not, I think, caused by lack of interest on the part of students. I do not think students come to university with fully formed expectations, I think they come as empty vessels hoping to be filled up. But systematics has been simply crowded out of the syllabus. When I think back to my own course in zoology in the middle 1950s, the dominant emphasis was in systematics. We drew the skulls of every order of mammal, learned their characteristics, drew the patterns of wing venation in every order of insects. All this took up perhaps 60 per cent of the course. But this was largely systemation learned by rote, there was little or no explanation of why the classification of each group should be the way it was. There was no sense of intellectual challenge. This is perhaps partly why the

subject has dropped out of the syllabus, but I think much more importantly it has just been pushed out of both the syllabus and the staffing level by competition from molecular biology in particular and from vastly increased fields like ecology, biochemistry and so on. Once one no longer teaches systematics the university no longer employs systematists and so the expertise has gone, students are simply not exposed to anything that would incline them towards systematics. I know in the Museum the experience is that, even when one has a funded studentship, it is quite often very hard to find high quality students. This goes back to undergraduate level, I am sure.

886. Yet it is said that taxonomy in its wider definition is extremely important both theoretically at the present time and also in practical utility.

A. I agree with you, yes.

887. So something has to be done?

A. I believe so. I think we have to have some sort of shot in the arm to get things moving again. I heard Professor Heywood refer to the situation in France. He said that twenty years ago in France systematics had simply been dropped, made part of pharmacology. In my own field of zoology that is certainly not true. I sat on a committee in Paris last summer giving grants specifically towards interdisciplinary aspects of systematics and bringing systematic projects concerned with morphology, palaeontology and molecular biology together. A lump of money had been found for this. This is a minor initiative but it is a pointer.

888. You say there is an opportunity to do something good and, without it, the university situation is in terminal decline?

A. I believe it is, yes, unless something is done at that level.

889. We were told rather surprisingly of a very popular course which is an option in the University of Oxford which has always had apparently an animal kingdom course in zoology which proved very popular. Does that coincide with your experience?

A. I know that there is a new course in systematics beginning in Oxford now, run by two young men one of whom has come from the Museum, and one from Cambridge. I know that in America when courses in systematics are taught they prove to be extremely popular. I have close knowledge of three such courses, one in Michigan in general systematics, and two in fish systematics, one in New York and one at Harvard. The American practice is to ask students to grade the courses they have attended, then to publish the league table, and I know all three of these courses consistently come out right at the top of the table. So the interest is there if it can be stimulated.

Lord Adrian

890. Let us agree that what actually happened was that a lot of positions in zoology departments of universities which had been held by systematists became held by cell biologists or whatever it might be. You yourself referred to your teaching and I myself a few years earlier took a course in Cambridge

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[Continued]

[Lord Adrian contd.]

in vertebrate zoology which was essentially systematics. I would not agree that it was taught by rote; as I recall it, I was absolutely fascinated by the comparative morphology of vertebrate skulls.

A. I think I know who would have been teaching.

891. It was a very stimulating course—at least I found it so. Given that in the 1940s and 1950s systematists in zoology departments were in fact teaching courses, and teaching 60 percent of the courses, one wonders how it was, if they were in control of departments, they were displaced. Either they abdicated or they were forced out. Can you tell me what actually happened there, because it seems to me to be difficult to understand why systematists who were—I will not say in control—a large part of the courses should suddenly disappear.

A. I think my problem in answering that is that my experience is in museums and not in universities.

892. Is that part of the problem, that the museums—actually institutions other than higher education institutions—so attracted people who were going to do systematics that they in a sense voluntarily left the universities, they did not see that teaching was important in terms of the temptation to go to museums and actually do the systematic work?

A. In my own experience, Lord Adrian, that certainly is not true. I know when I was considering moving from university teaching into the Museum I was very much advised against it as going to a dead-end profession. I have to guess at this but I would think that it was Watson/Crick's discovery and the follow-up from that that excluded systematists from the universities. There was this wonderful vision of how we might come to understand life in which systematics initially played no part.

893. I am aware that this is the usual interpretation. I find it difficult to marry up with the fact that, in fact, so many biology departments were, if you like, staffed substantially by systematists, and that is where my difficulty arises?

A. Yes, I think in part there must have been a generation effect, that the generation coming back from the war were replacing an earlier generation of systematists and their attention was turned elsewhere, but I have to say I am merely guessing.

Chairman

894. Perhaps we could come back to the importance of these collections which we have in this country, which are a product of our history but still are of enormous international importance. That is true, I think, is it not?

A. Certainly it is.

895. We have a special responsibility internationally for the curation, maintenance in good order and accessibility of those collections. It was mentioned to us in one piece of evidence, I remember, that if the United Kingdom was not behaving responsibly towards these collections it was in a sense surrendering its right to have them, and perhaps they should be returned to their countries of origin. This came from a developed country, I may say.

A. Yes. I think it was also suggested in the Royal Society's submission. An institution like the Natural

History Museum with its unrivalled collections is almost monolithic. I think if one were to think of chipping bits away from it the thing would collapse. I think we cannot avoid the fact that we have a responsibility. The fact that it has come out of our history is unavoidable. The responsibility is there and the point was mentioned earlier about the fuss last year about the Museum's corporate plan. I would differ from Professor Heywood on the reasons for that. I do not think it was a "knee jerk". I think it was a feeling amongst the world's systematists and other biologists, all of whom have used both the collections and the work of the Natural History Museum, that there was a prospect here of these totally unique institutions simply crumbling away.

896. Is that a view which you share?

A. I think here we get into one of the questions that was put to me concerning the difference between care and maintenance and full curatorial activity. May I talk about that now?

897. Please.

A. It is not a question that can be answered in terms of absolutes because there is no accepted definition of either of these terms, care and maintenance or full curatorial activity. One has to think in terms of analogy. The term "care and maintenance" came into the Museum profession I think from the military. It refers to the practice of mothballing destroyers and things like that. That is one sort of analogy. I can think of a situation that matches it. Until fairly recently if one went to the National Museum in Paris and wanted to look at the type specimens of fishes, one could only look through the glass of the bottle. One could not take them out and handle them. The reason given was, "We cannot get the pigs' bladders," which was the method that Cuvier and his successors had used to seal the jars. These collections had effectively been mothballed in pigs' bladders, but I think that it is not much harder to find a substitute for pigs' bladders than to recommission a mothballed destroyer. A closer analogy with care and maintenance would be the Science Museum library. When I first became interested in molecular biology in the early 1980s the museum library did not take the journals I needed and so I went round the corner to the Science Museum library. If I go there now and look in the Serials Catalogue for journals like "Cell", "Nucleic Acids Research" and "Journal of Molecular Biology", after each of the titles it says, "Dead", which means that funding cuts during the 1980s have cut those journals out, and so that part of the library has gone into care and maintenance. The back numbers of the journals are still available but not the recent issues.

898. Are you referring to the Science Museum library or the NHM library?

A. The Science Museum. They have gone into care and maintenance in the sense that the serials are cut off but the back numbers are available. It is obvious that the kind of researcher who uses that part of the library will have only an historic interest. He will not be interested in the present state of the subject, and the same follows for a specialist museum collection in care and maintenance. People who go there will be

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[Continued]

[Chairman contd.]

interested in historic problems. They will want to see the type specimens or the collection made by a particular person; they will not be interested in the cutting edge of the subject. So the notation "Dead" in a catalogue is a reasonable description of care and maintenance. The alternative, the term "full curatorial activity", can mean almost anything. To me the essential difference between care and maintenance and full curatorial activity is one of responsibility. In a curated collection, that collection is somebody's prime responsibility, their main focus of interest and attention. In care and maintenance, that collection is peripheral to somebody's main responsibilities.

899. But I think the test, if I were an outsider, of whether the Natural History Museum or any other museum was living up to its responsibilities would be whether I, wanting to come to the Natural History Museum, knowing it had material which was absolutely unique here, could get at it easily without let or hindrance. Does putting it into the "Dead" category make it very difficult to get at it or not?

A. It should not. A lot will depend on the previous level of curation before the thing became fossilised. If there is a good catalogue and if the person in whose care and maintenance it lies is sufficiently familiar with the collection, one should be able to find what one wants, but I know of instances where that is not now possible. But the collection is accessible and you should be able to find things yourself. But there is an enormous difference between that and going to a properly curated and researched collection, where there are people intimately familiar with the collection who can direct you immediately to what you want and frequently will be familiar with things that should also concern you.

900. When we visited the Natural History Museum, as it happened, chance favoured the unprepared mind in my case in that we went to the spirit house and saw fishes in just the kind of bottles that you have described, though I would not say they have pigskins sealing the jars!

A. No, they have glass stoppers.

901. It was pointed out to us there that the man responsible for this was very knowledgeable about it and had a lifetime of working there, but there was nobody coming up, as it were an apprentice, who knew about it. Is that a point of criticality which should not be gone beyond?

A. It has been gone beyond once a collection becomes care and maintenance because, as I said, the man you saw there felt that collection was his prime responsibility, that was what he was employed to know about, to understand. Once such a collection goes into the peripheral responsibility of somebody, you have reached that point. The great museums work largely by this system of apprenticeship. In my own position I am the third in succession on fossil fishes since the Museum opened in South Kensington. We feel part of a tradition that is broken only with great hardship.

902. But you can give a service which is unrivalled because of that apprenticeship. Is there anybody to follow you?

A. I cannot answer that, Lord Dainton. What happens after I go is not my concern. I am unable to influence it. I believe that in the present course of reorganisation of the Museum, one of the major aims is to separate research from curation. I have experience of several Museum specialists who have convinced themselves that their responsibility is full-time research rather than the collection. Some have continued to produce high-quality research, but most of them have devoted all their time to writing semi-popular articles and other peripheral activities. Without exception when those people left, the collection was in a shambles and it took the next generation to put things right again. In my own museum, in my own field, if I look back to the people I see as the giants in research, that would be Tate Regain in recent fishes and Sir Arthur Smith Woodward in fossils, I see the evidence of their curatorial work everywhere in the collection, in handwriting on labels, in the arrangement of the collection, in notes left on particular problems. I think once museum scientists are encouraged or permitted to believe they are not responsible for the collection, then that is the road to ruin. After all, why should a museum employ such people if their prime responsibility is not the collection?

Lord Flowers

903. I understand your saying you cannot influence the appointment of your successor—of course not. But do you at least know there are people you would feel were capable of carrying on your job if they were chosen to do so?

A. Within the museum or in the country?

904. Either?

A. Yes, there are.

Chairman

905. Not within the museum?

A. Well, I have a colleague in the museum—I am fortunate there are still two of us there. Beyond that I know of one person who has been trained in this country in the field and is well able to take on the task. But there is a curious history of interchange with this. Within the last ten years in the American Museum in New York the senior research posts in recent fishes and fossil fishes have fallen vacant and both posts were taken by people from London who had been trained in the Natural History Museum. Yet last year one of the senior posts in recent fishes in London became vacant and of the candidates who came forward for interview none from this country were trained fish systematists, and the person who was employed was a graduate from the American Museum in New York. This must be a symptom of the falling away in this country of training.

906. Some would say that was a desirable symbiosis across the Atlantic.

A. Certainly, yes, it is evidence of close co-operation in the past between the two museums and willingness on both their parts to look outside their immediate neighbourhood.

907. Are you saying that nonetheless there is a shortage in this subject at the present time of people

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[Continued]

[Chairman contd.]

and resources which is missing the chance to do good work at the present time, and that it affects our standing and also the quality of general biological research and teaching? I am trying to get a handle on what you really think.

A. Several of the questions that were sent to me, both for Professor Heywood and myself, talked of a malaise in systematics. I think that is behind your question. I certainly do not believe there is a malaise in systematics. I think there is a malaise in systematics in this country but not elsewhere. In North America I have already mentioned the quality of some of the courses that are taught. The leading journal in my field in zoology is "Systematic Zoology" published by the American Society of Systematic Zoologists. This year both the Journal and the Society have replaced the "zoology" in their titles by "biology" to indicate a widening of interest of the membership and in the field of the journal. Last year "Systematic Zoology" published an editorial on the status of the journal and of systematics. It was pointed out that in the impact ratings of the Science Citations Index (I do not know how seriously these things are taken but they exist) the journal "Systematic Zoology" over the last ten years has consistently ranked first or second amongst 100 journals in zoology, right at the very top. It also pointed out that journals like "Evolution" and "American Naturalist" are now publishing far more papers in systematics than they did ten years ago. I think this is all evidence not of a malaise but of life, of growth of interest. I think in this country we are failing to take part in this.

908. Could I ask a crucial question for us? Are you saying because it is not growing to the same extent as in other countries, left to itself, systematics will recover automatically—there is, if you like, a mechanism for repair of the system that is spontaneous, that the nature of the subject is such generally in the world that people will have to do something about it within present resources—or are you saying it is necessary, if one is not to go into terminal decline, for some active intervention?

A. The turn around, if it comes, will have to come at the undergraduate level, I believe. Given the present state of university biology departments, in my limited knowledge of them, I think it is inconceivable that they will begin hiring systematists in present conditions. University departments tend these days to hire the people who they think will bring in the most grant money. We have already discussed the situation for funding grants in systematics in this country, and, as you put it earlier to Professor Heywood, systematics has been put on the back burner. So I think there are two levels where there has to be some sort of new initiative. One is to move systematics from the back burner in grant funding. The second is somehow to reawaken interest in university departments and the new course in Oxford is a splendid pointer to what might happen. Of the two young men who are running that, one is employed in the museum in Oxford and the other is there on a three-year fellowship. He is not a permanent member of staff, so the life of that course may well be a short one.

Lord Butterworth

909. To follow this a little further, it is probably not wholly fair to ask you this question, because you say your experience has been with the museums, but looking at it, as it were, as a lawyer and not as a scientist, and listening to this, I wonder if it would be fair to say that those who have constructed biological courses in universities have failed us because they are not now training the kind of people who are needed in order to do the kind of work that you have been describing? Who is responsible for having produced biology courses all over the country which have resulted in these areas not being given sufficient attention?

A. I am afraid I do not know the answer to the question. As I said, my background is in the museum and I have no knowledge of how universities' syllabuses are constructed. Presumably they come from the board of studies of the university.

Chairman

910. I think perhaps part of the explanation may be in the fact that funding of the universities now is largely on a formula basis that relates to research activities and, therefore, as you said yourself earlier, there is a reluctance of universities to put money in particular areas which I think you said do not attract funds.

A. Yes.

911. If you add to that that there is virtually no contact between the Universities Funding Council and the Advisory Board for Research Councils, the chief executive being no longer a member (this came out in evidence to another Select Committee), then I think you really have to re-establish those routes of communication before any sensible central action can be taken, do you not?

A. Yes.

Lord Adrian] To follow up on what you said, my Lord Chairman, I was going to make the point that the decline in systematic teaching in universities happened, I think, very substantially before any direct funding difficulties. The funding difficulties may have added to the position but the position was that the decline in systematics happened, I would have said, in the period when university funding was at its most liberal in point of fact, in the 1960s and 1970s.

Chairman] Present arrangements make it much more difficult.

Lord Adrian] One has, I think, to look for the cause of decline outside financial reasons.

Chairman

912. How is one to put it right? It does seem to need, does it not, some initiative to put the balance back where it ought to be. That seems to be your view.

A. It is, yes. One can see it, I think, only in two areas. One is in terms of funding and I think we have talked about that as far as I am able to go. The other, of course, is in the links between the institutions and the universities. They had been extremely poorly organised. Many members of staff of the Natural History Museum have taken part in teaching in the

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[Continued

[Chairman contd.]

University of London and elsewhere, but so far as I know, that has nearly always been on a casual basis of arrangements between individuals. There is very little in the way of formal arrangements between the Museum and the universities. Because of geography it would obviously be better if London University were to co-operate with the Museum rather than any other university. We have signs of official links with Imperial College in palaeontology, where we now have one joint appointment. Another in molecular systematics is planned, but beyond that, if one thinks of the American situation in New York, almost all the museum's research staff are appointed as adjunct professors in Columbia or City University or another of the several universities around. Course in systematics are taught in the museum and they are popular. I think if Natural History Museum staff were to teach recognised university courses in systematics this might do something to reverse the decline at undergraduate level.

913. But this is for the biological community to organise for itself really, is it not, as the particle physicists have done? They take their research students on courses, whether at Rutherford Appleton Laboratory or wherever?

A. The problem is that during the whole of my time in the Museum I and other colleagues have been trying to establish more links with the universities but it felt rather like intruding into a closed shop situation. Naturally within the universities, even in the 1960s when money was not quite so tight as it is now, they nevertheless saw the possible intervention of Museum staff in their teaching duties as a threat to their jobs. I am sure these days they would see it even more so. I think it would be better if the Museum were recognised as an official teaching body of the university simply in areas of its own expertise because there are virtually no systematists now employed in the universities. This would not be seen, I think, as a threat to anybody's job or funding.

914. It must have seemed an intrusion into private grief?

A. Yes.

Earl of Cranbrook

915. Can I ask one more question based on past personal experience of the relationship between the exhibitions in the Natural History Museum and systematists. In the 1970s I was attached to a university which had no connection with the Museum and I was encouraged to use the publicly displayed material in the Museum for demonstration purposes in a course in comparative vertebrate morphology and systematics. In those days in the early 1970s the displays were accessible and extremely useful for this old-fashioned kind of teaching. It would be difficult to do the same now. Do you feel that is a regrettable feature of the new change in the Museum or do you welcome the more cognitive exhibitions now on display?

A. There is nothing non-cognitive about comparative morphology. I think it is extremely cognitive. In my own area, the fossil fish gallery, a large part of which I was responsible for, was the most advanced textbook in the world; it had all the best specimens in the world and all the latest

information. A colleague and I put it together. He is now Head of Exhibitions in the Museum, and at his instigation we tried to do a cost-benefit analysis. It worked out that the number of people who had been through that gallery who were capable of getting out of it something of what was there, that it probably cost the nation, I think, £1,000 a head. I think that the practice in all the London colleges, of sending students to the Museum for days at a time to take their comparative morphology courses from the exhibitions, was perhaps the reverse of what I was talking of, the suggestion that the university was unwilling to have us as teachers except on those terms. I do not know if you saw it in this way but I know several lecturers who thought, here is a way of getting some time for my research. I will send the students down to the Museum. They can no longer do that.

Chairman

916. I think that is a suitably depressing note on which to finish, unless there are any points that we failed to elicit but that you would like to make, or whether there are any things you would like to say now which you have not had an opportunity to express?

A. I think not. Some of the questions that were put to me we have got nowhere near, things to do with cladistics and so on. I think my views on that sort of topic are so different from Professor Heywood's. Yes, perhaps I might comment on one thing which was so obvious in Professor Heywood's evidence, that he saw a dichotomy between the service aspects and the research aspects of systematics as a serious problem, as a deficiency in the present state of systematics. I would like to argue against that point of view. My own experience of the service aspect is limited. It is confined to determining specimens brought in by the public or by other researchers, or things sent in by oil companies or geological surveys. In that work I have found absolutely no sign of any sort of dichotomy between the service aspect and the research aspect. When these things come in, if I know immediately what they are I know because of my research and, if I do not know what they are, I have to do some research. The research is almost always more than just pulling drawers out and looking for a match. If an oil company sends in some specimens, the report one writes on them always goes far beyond the simple matter of what are the names of these things? It concerns abstractions—the stratigraphic range of groups, problems of palaeobiogeography and so on. During my time in the museum specimens brought in by the public have been a most valuable source of research material. I see absolutely no dichotomy between these two aspects. I think the service aspect necessarily can only grow out of the research aspect and yet it has its own input to the research aspect, and that is a valuable one. So about that I would disagree profoundly with Professor Heywood.

Chairman] Thank you very much indeed, Dr Patterson.

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MINUTES OF EVIDENCE
TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**

(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 16 July 1991

Dr F A Bisby

Professor R M May

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Members present:

Butterworth, L.	Nicol, B.
Cranbrook, E.	Porter of Luddenham, L.
Dainton, L. (Chairman)	Walton of Detchant, L.
Flowers, L.	Whaddon, L.

Memorandum by Dr Bisby

Written evidence to the Select Committee on Science and Technology Sub-Committee II—Systematic Biology Research

1. Systematics research covers a spectrum from the study of evolution to the production of a reference system of all living things. The need for research changes between the two domains: the first may be purely scholarly with exciting discoveries using new techniques; the second requires scholarly work but is driven by utility.

2. Fundamental research to produce monographs and above all the related assembly of reference works (Floras, Faunas, handbooks, information systems) are of the greatest importance to mankind. They are the only means we have to enumerate species diversity and to provide a catalogue of living things for biotechnology, agriculture, the pharmaceutical industry, conservation and regulation. I am concerned that it is practically impossible to fund work on the reference system of living things outside the large institutions (and increasingly within them) despite the strong record of British systematists.

3. Research and development of systematics applications of information technology has been spectacularly low. Only three small bioinformatics laboratories and two small software partnerships exist in Britain and involvement at the NHM and Kew has been insignificant.

4. I recommend:

- (i) a substantial and longterm fund available to species diversity research.
- (ii) a short-term initiative to stimulate research and development of information technology in systematics.

Introduction

This evidence is submitted by Dr. F. A. Bisby, Senior Lecturer at Southampton University, recent botanical secretary of both the Linnean Society and the Systematics Association, chairman of the IUBS (International Union of Biological Sciences) Commission on Plant Taxonomic Databases and representatives of IUBS at CODATA (Committee for Data in Science and Technology). My own research is into species diversity information systems—the provision of taxonomic reference systems and the organisation of species-based information sources. I was the instigator of both the developing ILDIS (International Legume Database and Information Service) and the GPSIS (Global Plant Species Information Service) initiative, and I am on the organising committee of Flora Europaea and the SPP (Species Plantarum Project).

ILDIS is an international co-operative project to provide a database and worldwide service with a single taxonomic reference system for all of the world's Leguminosae (about one twelfth of the world's plants), and additional datasets on applied botanical data such as phytochemistry, biotechnology, germplasm resources. The project has received enormous support in kind from institutions throughout the world and is cited as a prototype for taxonomic information systems of the future: but funding the co-ordinating centre, software and international organisation has proved near impossible. Phase 1 has received approximately £1½ million of seconded assistance over 6 years from institutions worldwide (United Kingdom, Germany, USA, USSR, China, New Zealand) but has been badly hampered by having to survive on grants totalling £160,000 over the same period for the co-ordinating centre and software. An attached letter illustrates the refusal of SERC to consider further support despite its involvement at the start.

The Species Plantarum (SPP) and Global Plant Species Information System (GPSIS) are linked initiatives, the first to generate rapidly a taxonomic checklist of all the world's plants based on the best of present knowledge, the second to develop a computer system to deliver worldwide this and associated data on all of the world's plants. United Kingdom centres (Kew, Southampton University) and United Kingdom information industry (CAB, BIOSIS United Kingdom, Chapman & Hall) play a major rôle in both initiatives with European, US and Australian partners. They are exciting initiatives addressing mankind's desire and need to know the extent of species diversity as a resource. They require major (but not massive) support from international agencies such as UNEP and IUBS, plus substantial support from the major participating nations of which the United Kingdom is a leader. Once established, and if properly managed in partnership

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with the information industry, these systems may in time come to recoup a major fraction of running costs through charging, but the initial investment (possibly £20 million spread internationally) cannot be recovered. In the context of world environment expenditure these amounts are small.

(i) *Utility*

Systematics research covers a spectrum from the study of evolution to the production of a reference system of all living things. The need for research changes between the two domains: in the first the emphasis is academic enquiry, to learn more about the evolution of life; in the second the emphasis is on utility, to specify the map of diversity.

The central element to the utility is the creation of a reference system for organisms (the taxonomy) and making this reference system available for use by the biological professions. Creating it requires monographic research. Making it available requires reference works such as handbooks, Floras, Faunas and, increasingly, computer information systems. The reference system created is "the taxonomy" which has four components, the classification itself, and dependant on this, names, identification aids and descriptive data.

- Taxonomy*
- (i) Classification
 - (ii) Names
 - (iii) Identification aids
 - (iv) Description or pictures

In many contexts the core minimum on which the reference system depends is a workable or agreed synonymised species checklist.

Direct utility

A number of disciplines make direct use of the taxonomic reference system. They directly access taxonomic sources for information on classification, names and synonymy, description and identification. They include:

- (a) United Kingdom field ecologists, conservationists, foresters, agriculturalists, environmental consultants working with plants encountered in the wild and in cultivated ground both in United Kingdom and abroad.
- (b) germplasm and genetic resources disciplines including international agencies (e.g. International Board for Plant Genetic Resources, FAO); national genebanks and agricultural agencies (e.g. former Welsh Plant Breeding Station, Wakehurst Place RBG Kew, Instituto del Germoplasma Bari Italy, United States Dept. of Agriculture Beltsville) and commercial plant breeding companies (Nickerson's, Suttons).
- (c) pharmaceutical research organisations extracting from plants worldwide (e.g. Beecham's, former Smith, Kline, French, Glaxo, ICI) and the phytochemical information services they use (e.g. CAB International, BIOSIS (Biological Abstracts), Chapman & Hall Scientific Data Division, NAPRALERT Chicago, Chemical Abstracts Inc.).
- (d) biotechnology, industry and molecular biology research, the information services that they use (eg ICI, Shell, EMBL, GENE BANK) and the regulation bodies (eg CEC, EPA (USA), OECD Paris).
- (e) nature conservation and biological recording organisations both large and small (eg NCC, IUCN, WWF, The National Trust, County Records Centres, County Conservation Trusts, The Hawthorn Centre Southampton Common), the information services they use (eg WCMC Cambridge, The Nature Conservancy Washington) and conservation/trade regulatory bodies (CITES, Berne Convention, APHIS USA, The Council of Europe).
- (f) botanic gardens and museums both large and small (eg Gardens Division RBG Kew; Ness Botanic Gardens Wirral, NHM Displays Dept., University Botanic Gardens at Southampton and Reading etc, Tudor House Museum and Tudor Garden Southampton, Leicestershire Museums etc) and related services (eg IUCN Botanic Gardens Secretariat, Richmond).

Added Data Utility

A substantial subset of these disciplines make further use by additionally drawing on descriptive, geographical pictorial, biological data often provided in taxonomic works. An example is the work of IBPGR in comparing known geographical distributions of plants obtained from taxonomic works with the extent of germplasm collections reported by germplasm centres to assess the completeness of coverage.

Added data utility is an area for development in computer species diversity information systems. For instance ILDIS is developing a phytochemical dataset linked directly to its computerised checklist of Legumes so that users can query substances recorded for given plants or plants in which given substances occur.

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[Continued

Third Party Utility

It is my belief that whilst the usages listed above ("direct utility" and "added data utility") could be quantifiable, they represent the smaller fraction of society's usage of systematics. The other fraction, possibly the "larger", is what I call third party usage—usage of taxonomic units, names, groups, evolutionary patterns in communications and concepts by professional biologists who have no direct contact with systematics or its reference works. Indeed if questioned these biologists may claim that they have no use themselves for systematics. Examples occur in every scientific journal, every lecture, every grant proposal, every television programme or child's booklet that has a biological component: an agronomist reports on pest problems in grain legumes; a physiology lecturer describes the C3 pathways in different plant families; a biotechnologist applies for funding in developing molluscicides from transgenic legumes, British Airways gives its "young flyers" a colouring book that clearly depicts the differences between African and Indian elephants. In myriad ways the taxonomy structures our thoughts, concepts and vocabulary throughout biology. It is a simple matter to show children the differences between hive bees, bumble bees and cuckoo bees, or to show students the resemblances between cockroaches and mantids: but each is the product of earlier scholarly work by taxonomists now diffusing into the current concepts of biology.

Examples of utility

- 1) Flora Europaea—5,000–6,000 sets sold
- 2) Viciae Database Project (1979–1983)
 - sample of 100 enquiries received included those from
 - plant breeders
 - phytochemists
 - archaeologists
 - conservationists
 - medical research
 - ecologists
 - contract from United States Dept. of Agriculture (2,000\$) to provide leaflet containing checklist, descriptions and chemical data.
- 3) ILDIS
 - contract from IBPGR for taxonomic data on all *Vigna* species (1,000\$) for plant genetic resources work.
 - grant from IBPGR for access to ILDIS Database for plant genetic resources work.
 - £55K contribution from Chapman & Hall Scientific Data Division to ILDIS Phytochemical Dataset for tracking plant sources or natural products.
 - Symposium "Designs for a Global Plant Species Information System" (GPSIS), sponsored by CEC DGVII Biotechnology Programme, Chadwyck Healey plc, CAB International, BIOSIS Inc., and Chapman & Hall.

(ii) Specification of organisms

Yes. My work on taxonomic information systems includes delivering precise taxonomic specification of legumes to people working in biotechnology, plant breeding, pharmaceuticals, and biotechnology regulation.

(iii) Level of UK research

The level of UK Research is appropriate in one area, but inadequate in two other areas.

- (a) It is adequate for evolutionary systematics. Here the research level will wax and wane in quantity as the style, techniques and philosophical interest of new investigations move on and as their ability to compete with other developments, either at the research councils or in the institutions, varies. The emphasis is primarily academic (with important exceptions) and so there is no uniform absolute level required other than by its current level of interest in the context of overall biological research.
- (b) It is now inadequate, grossly so, for the research needed in producing the reference system for organisms. Despite the outstanding international record of British systematists in Universities in the recent past (e.g. Flora Europaea, Flora of Turkey), it is now virtually impossible to fund fundamental work on monographs, and on producing reference works such as Floras, Faunas, handbooks and information systems outside the large institutions, (and increasingly within them too). Such works are of the greatest importance to mankind. To enumerate the species diversity of the world is of considerably greater significance to humanity than the Human Genome Project. It is our only means of providing for knowledgeable work on bio-diversity, conservation and the response of biological resources to global change.

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(iv) Areas for United Kingdom Research

Molecular and evolutionary biology aspects of systematics compete well and probably receive a satisfactory share of SERC, NERC, NHM and Kew funds. In contrast there are two areas in which United Kingdom is strong but in which overall funding has recently become inadequate—basic diversity research (both monographs and taxonomic works), and bioinformatics for systematics (databases etc.).

The Committee may wish to consider the following as guiding principles:

- (a) Systematics is global. United Kingdom systematics research must be set in the context of international cooperation. In biotechnology, pharmaceuticals, agriculture and conservation United Kingdom scientists work with organisms from anywhere in the world. We should therefore ensure that we develop the United Kingdom rôle by maintaining skills, involvement and awareness as part of the international community, and we should encourage that community to produce the reference works needed by United Kingdom science and industry.
- (b) The systematics research with the greatest utility may be different from the systematics research with the greatest biological and academic interest. In monographic and floristic research consistency in high quality survey is needed, and not successively newer biological techniques or theories. In bioinformatics high quality research followed by in-depth development work is needed: the problems involve engineering as well as design concepts.

(v) Reference Collections

Reference collections at the NHM, Kew and the Linnean Society are a resource of global significance, unrivalled even in the USA. The question of how important they are for United Kingdom research is insignificant alongside our responsibility to the rest of the world. We owe it to mankind to secure their adequate curation with a judicious mix of United Kingdom and international resource.

(vi) New methods

Bioinformatics (biological applications and developments of information technology) holds a special potential as so much of systematics involves the collation, analysis and dissemination of information.

One prospect is the more efficient handling of information within taxonomic research. This might start at computerised organisation of the usual data and extend to sophisticated new options such as desktop experimentation and comparison of taxonomies, and the computer-assisted generation of taxonomic products such as identification aids, knowledge systems and graphics. Another prospect is the use of databases, information networks, graphics and video, identification aids and knowledge systems to revolutionise the delivery of taxonomic reference works to those in other professions—agriculture, conservation-diversity, phytochemistry and biotechnology. But we need to be clear that such tools require much research (conceptual and design interactions with working taxonomists and users) and considerable investment in development if working prototypes are to become usable as every day tools. Today's scientists have ever growing demands for the friendliness and 'intelligence' of information technology and these require substantial resources beyond those available in United Kingdom at the present. The complicated structure of taxonomic data and the difficulties of handling biological variability also often require the full sophistication of tools that are only now becoming available.

A number of United Kingdom based projects are in progress in software development (e.g. ALICE, RHS system, CAB in-house systems) and in establishing working information systems (e.g. ILDIS, CAB Mycological Institute, the Palaeontological Record) and identification aids (e.g. PANKEY and PICT-ID systems). A number of United Kingdom institutions participate in the production of taxonomic database standards by the IUBS Commission for Plant Taxonomic Databases and the United Kingdom has provided a number of its officers (Heywood, then Bisby as chairman). Other initiatives are planned: such as the BAOBAB, GPSIS and SPP software; Compositae, and Gramineae ILDIS-like systems; the SPP and GPSIS information systems. Yet there are only four small bioinformatics for systematics laboratories (Nottingham, York and Southampton Universities, NE London Polytechnic and only two small specialist software partnerships (the ALICE partnership and Hand, Whittington Associates), all struggling because of spectacular under investment in information technology by the systematics profession. Involvement by NHM and Kew has been insignificant—at NHM the relevant person was one of those made redundant, at Kew the relevant person is not on the permanent staff. I repeat that much of systematics, like say commercial banking or government health management, is pure information handling—and yet a comparison of the investment of a modest commercial bank; the Department of Health Information Systems Directorate and the *entire* world systematics profession is spectacular.

Evidence of under development

- (a) In the mid-80's SERC funded a 3-year design and prototype project in my bioinformatics laboratory at Southampton for a taxonomist's desktop data handling system called BAOBAB. SERC was subsequently unable to fund development of the system from the prototype onwards and it has still not been implemented. There is now a widespread need for this software.

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- (b) A large number of taxonomic reference work projects (including United Kingdom-based ILDIS, ESFDS, Flora Europaea, SPP and many projects elsewhere such as Med-Checklist at Geneva, Flora North America etc.) need software to handle the collation and public access to a taxonomic synonymised checklist and taxonomic hierarchy. Not one project or institution has been able to invest, or co-ordinate the investment in first rate software that could be used all over the world. Inadequate underfunded attempts have been made by many projects (ESFDS, Med-Checklist, Flora North America) and the best available, the ALICE system with all its limitations, has arisen through the extraordinary commitment of unpaid associates of the ILDIS project, now the ALICE partnership.
- (c) Recent developments in graphics and video handling have still to have any significant effect on the potentially rich area of applications in systematics—images of organisms, GIS and maps, pictorial identification, pictorial educational systems. Again there are just a few underfunded efforts.
- (d) The work of the IUBS Commission for Plant Taxonomic Databases in preparing standards for data exchange and taxonomic database structuring has been badly delayed by lack of resources. Those doing the work, the few experts that exist at taxonomic centres, are all overstretched and support, albeit modest, is needed to speed the work. There is a real danger of the standards becoming available too late to assist the main pulse of developments.

(vii) *Institutionalisation*

- (a) There are significant problems with the institutionalised base of much systematic research. One is that reference work funding is mistakenly concentrated there despite the high reputation of projects initiated in the Universities (Flora Europaea, Flora of Turkey, European Garden Flora, ILDIS), often because the non-institutionalised projects gain higher levels of collaboration both internationally and with national experts. Secondly research projects in the institutions have not been through the rigours of competitive grant application, and it shows.
- (b) A radical solution to the NHM funding problem is inevitable. Now that the systematics staff and the systematic collections are no longer used for creating educational displays etc. the original reason for housing systematics and the educational displays in one institution have disappeared.

So:

- the NHM should be split into two institutions
- one would remain the NHM in the NHM Building as a national educational museum under OAL
- the other would become a national *and international* systematics institute (collections and systematics staff) under DES (possibly new purpose-built storage and labs at Swindon under joint SERC/NERC/EC control).

(viii) *Who pays?*

- (a) In principle parts of the burden should be shared both for maintaining reference collections and for international reference works. Unfortunately responsibility for species diversity is divided at the UN between FAO, UNEP, UNESCO and UNIDO, and at the CEC between DGV, DGVI, DGVIII, DGXI, DGXII and DGXIII. IBPGR and IUCN are key international agencies too. Although lacking in funds IUBS/ICSU are the international agencies for taxonomy. Hence the need to establish *species diversity and systematics* as a major feature of the planned UN Accord on biological diversity—with funds.

In practise I feel the CEC, IUBS, UNEP and FAO are the most likely to play an effective rôle: but no effective agency and no adequate funds exist at present. ESF has been a minor player so far.

- (b) Within the United Kingdom there should be two provisions:
 - (i) a substantial and long-term fund available to species diversity research. This should be available for two categories of research put forward from any institution (universities, polytechnics, local museums, voluntary bodies, national institutions). One category should be very high quality larger monographs done by one person over a number of years (5-10 year projects with intermediate review). The other should be for major reference work collaborative projects—such as Flora Europaea, Garden Flora of Europe, ILDIS or the coming SPP and GPSIS projects. In these consortia of laboratories or institutions would apply, the funding supplied would usually be a fraction of the total (e.g. a United Kingdom contribution), it would be planned over a long time span (5-20 years), and with regular review process built in. As the total commitment would be substantial, but not enormous, there would clearly be very great competition for these funds. The principle would be for a very few regularly reviewed long-term projects financed in depth.

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- (ii) a short-term initiative to stimulate research *and development* of information technology in systematics. It is clear that greater efficiency and better products could be available if only information technology were better developed for use in systematics.

This should be a 5-10 year special initiative organised by SERC. It should be recognised that, like much engineering research, this is to be for development as well as pure research.

- (c) I think industry can play a rôle. There have been some modest developments with the information industry. Chapman & Hall Scientific Data Division has invested in part ownership of the ILDIS Phytochemical Module, and BIOSIS has given modest support both to ILDIS's email network and the launch of its on-line service next year. Similarly Flora Europaea has used its substantial publication royalties for research and is discussing the development of a database with its publisher Cambridge University Press. Several parts of the information industry have expressed interest in the coming SPP and GPSIS projects.

The other question is whether taxonomic user communities can support systematics either through joint development or the paying of realistic fees. The outstanding example is CAB International's use of its information and biological services to support taxonomic research and production of reference works in fungal and insect taxonomy.

(ix) Teaching Adequacy

The teaching of systematics skills, and even the teaching of basic familiarity with the major groups is now very patchy. At my department in Southampton we still provide some undergraduate training (with fieldcourse) and do train PhD taxonomy specialists in Leguminosae and in bioinformatics.

For systematics training I think it would be better if taxonomists were concentrated in larger numbers in fewer departments, as with the widening range of skills, no department can give the necessary depth. But for some reason systematics is held in low esteem and almost no department seems willing to take more than one onto its staff.

(x) Learn from Abroad

We should emulate two initiatives from abroad. The national coordination and funding of plant taxonomic research in Australia appears to have worked well, albeit under very different circumstances to our own. Secondly the National Science Foundation (USA) has now started an initiative to stimulate directly database related developments in biology, its Databases in BBS Program.

F. A. Bisby

15 April 1991

Dear Dr Bisby

Experiments with Co-ordination and Consensus-seeking in the Taxonomy of the Leguminosae

I am writing to explain why the above grant application was considered inappropriate for consideration for funding by the present form of the Plant Sciences and Microbiology Subcommittee (PSM) and not suitable for any other peer review body operated by SERC.

Since our telephone conversation I have spoken to members of PSM in part responsible for this Subcommittee decision and have confirmed the reasons for such a decision.

The opinion of the Subcommittee is that the application proposed an exercise in information collation and did not contain the essential elements of scientific research required by the Subcommittee. The proposal did not involve any new experimentation or observations but rather its approach was clerical, encouraging consensus decisions by increasing taxonomists' awareness of already available information. The Subcommittee is willing to support taxonomic research programmes but this application was considered to have the wrong approach. Further applications would be welcomed if the aims are to break new ground in numerical approaches to taxonomy. Although inappropriate to PSM, the value of the proposed work was recognised.

I hope that this response clarifies the situation. I would advise you that before any future submission you might like to telephone or write to me with an outline proposal so that I can consider whether the proposed work would be appropriate to PSM before you spend time in writing a full grant application.

Lucy Watson

Secretary, Plant Sciences and Microbiology.

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DR F A BISBY

[Continued]

Examination of witness

DR F A BISBY, School of Biological Sciences, University of Southampton, called in and examined.

Chairman

917. Good morning, Dr Bisby. Thank you for coming and thank you also for your long and interesting memorandum, which was addressed in part to some of the questions which were sent to you. Since then you have received a copy of some of the questions we are thinking of putting to you?

(Dr Bisby) Yes, I have, thank you.

918. Perhaps you would like to make some general remarks, or would like to add to what you have already said in some way?

A. I do not think so, my Lord Chairman. What I would like to do is to try and answer your questions and there are one or two to which I think my reply is brief, but there are two to which I would like to expand on a couple of points if you would permit me. You start with the question which is addressed to both me and Professor May: it is widely agreed that systematic biology plays a lesser role in the universities' biology syllabus. Is this being crowded out, or is it because of diminishing interest? I really wish I knew how to answer that question. If I did know how to answer that question my own teaching, my own throughput of students would be so much more successful than it is in my own university. I have pondered this at great length and I can tell you of some strands but I cannot tell you the answer. One of the strands relates to the interests of students that come into my university. When I went to university I had been a keen natural historian as a teenager; I already had an interest in taxonomy before I went to university effectively. When I look at my own students, very few of them are keen field natural historians as they come in. Somehow we are drawing into the new biology a different range of interests and people with a different background in teenage.

919. Can I ask in that connection, years and years ago when the situation in school I was at was similar to the one you have described yourself there was a natural history society, there were also keen teachers who spent a lot of time outside school interesting boys in the subjects. Does that no longer exist as you go back to the schools, do you think?

A. I have no family of my own so I am on uncertain ground in describing what happens in schools at the moment. Certainly in my own experience it was my parents and my schoolmaster who led me to this interest.

920. We are also told and have been given evidence to the effect that, for example, anything relating to systematics has now become optional in same A level syllabi and because of its optional character and the weakness of teaching in schools that it has quite often been dropped. Do you know whether that is true or not?

A. Let me recount to you the very worst experience I have had. I had a tutee last year and when I asked her about some problems about her knowledge of major plant groups she said to me, "Oh, we did all the taxonomic hierarchy at school". I said, "If that is the case, you explained you didn't understand the difference between liverworts and mosses", and she said, "Oh, we did the whole lot". I said, "What did

you actually learn?" She said, "Oh, I learnt there was kingdom, phylum, order, family, genus, species", and she had merely learnt the names of the different levels in the taxonomic group but no instances of any particular taxonomic group. I was absolutely scandalised by this. This is the worst example I have come across.

921. Does this mean you may have to do *ab initio* courses within the university?

A. Yes. I run a field course for students in which they are having a basic indoctrination in the first two or three days of the natural history I would have expected a teenager to know before coming to university.

Lord Whaddon

922. The thought has occurred to me, when I was very young I was brought up in a completely urban environment and then for a year or two as a teenager in a rural environment. I found a dramatic difference myself in looking at the world and how it was made up, and suddenly understood something of what we are talking about. Have you any impression that the students from an urban environment have a different attitude from those from a rural environment? It suddenly occurred to me that there had been a dramatic change in the proportion of children growing up in an urban environment in the last few decades when the subject has been declining.

A. This may well be a contributing factor. It comes down to the same thing as learning about organisms or handling them. On the field course (and we have to fight for its existence in my department for financial reasons) it is the handling of the organisms that is so new to the students. It may sound ridiculous (and perhaps I am disgracing my own university by giving you this evidence) but genuinely on the first day or two of the field course we have to say to them, "You will have to bend down and pick the plants yourselves and get your own hands dirty", otherwise they expect me to do it for them. It is this distinction between seeing things on the video and in books and on television and seeing the real thing and handling the organisms themselves which is part of this natural history experience which I find so lacking in our students, and for me was the principal reason for entering professional biology.

Chairman

923. How do they take to it?

A. They love it. Their usual response to our field course is absolute amazement that the plants can be as interesting as the animals; it is a joint plant/animal course.

924. Is it a compulsory part of the biology course in Reading?

A. In our university it is compulsory for all biology students.

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DR F A BISBY

[Continued

Earl of Cranbrook

925. Could I ask if there is an urban wildlife group or any such organisation in Southampton?

A. Yes, very much so. I would not say our undergraduates become well involved in it. I would say some of our postgraduates do and some of our unemployed postgraduates have made a major impact in Southampton in setting up a wildlife centre.

926. Is that not reaching down to the schools?

A. Yes. I have no children so I am not in close contact.

Lord Flowers

927. If in universities it has been the custom to say, "All that stuff is very boring, what we should teach is molecular biology", some of these students become teachers and pass the same attitudes on to their students. We are dealing now with biology teachers who are themselves educated in this system of throwing out the old biology?

A. You have picked on a second strand and that is, I believe the ambience amongst university staff is somehow not to value systematic studies highly and this, unfortunately, does show. I find myself in competition with my colleagues even for the credit due to my own topic within the department.

Chairman

928. But you did suggest at one part in your written evidence that it would be a good thing to concentrate work in a few institutions. Now if you do that you lose this pervasive influence which you would like to see as affecting all biology students.

A. Let us make a distinction between undergraduate education and postgraduate education. The problem for postgraduate education is few of the university departments can cover the full range of skills needed in systematics. So for postgraduate study – certainly in my own biology department I end up sending my own postgraduates off for study periods elsewhere because I cannot cover the full range of skills myself. It is different from the undergraduates where I agree with you that basic systematics as part of the field work and part of the course work is essential for all. It is easy to say that but I believe it is not, in fact, available to all across the country. I believe that only a sub-set of universities even run the field work that we run.

Lord Porter of Luddenham

929. If I can come back to the schools for the moment. Again if it is true, as you say, that taxonomy and field studies are going on less in the schools, what is replacing it? Presumably they are still doing biology or are there fewer people doing biology? In other words, as part of this question asks, is it being crowded out by faster growing areas of biology in the schools?

A. I am sorry, sir, but I do not know the answer to that question. Let me give you one third strand and that is in our universities I find that some of the students with the kind of interests I am talking about do not take the degree in biology; they do the degree in environmental science. So the question of conservation, environment and bio-diversity, the

slightly broader aspect, may still be attracting some of these students but it may be there is a wider range of topics where formally a wider fraction of these people looked at systematics. I am not sure.

Lord Walton of Detchant

930. To what extent does the syllabus for GCSE biology and the syllabus for A level biology and zoology and the exams depend upon knowledge in this particular discipline?

A. I am sorry, sir, I am not sufficiently knowledgeable of these syllabi to answer that question.

Chairman

931. We interrupted you I am afraid but it led to an interesting conversation.

A. In question 3 you asked about CAB's suggestion that a separate funding body for systematics should be set up. I support this idea. I am not sure whether we need a separate funding body or a separate fund and organisation within one of the funding bodies but I support this and, indeed, I made the same suggestion in my own evidence where I talk of a substantial long-term fund.

Earl of Cranbrook

932. In your own evidence you talk about a fund for species' diversity research. Is that a synonym for systematics?

A. Yes, directed at biological diversity. If you will excuse me, I saw there were some questions directed to Professor May, not to myself, which are not related to those questions on biological diversity in systematics. By species' diversity research I mean as one dimension. If you look at the enumeration of the world of biological resources available to us in the world, as I say, not all aspects of systematics would fall within that.

Chairman

933. Some people would argue that the case for a new funding body is really to cover up the deficiency of the biological community, that it has itself allowed this situation to develop and it has now, as it were, suddenly wakened up to the problems. Various institutions have alluded to this weakening and perhaps the biologists ought to be allowed to compete simply on their own merits with other scientists in their applications for funds. Would you agree with this? What you seem to be arguing for is some kind of special initiative.

A. I think what you have outlined would be unlikely to occur, my Lord Chairman. I have myself competed at SERC and NERC for funds and I have succeeded in some of the applications where the application has clearly had some novelty to it, in terms of novel techniques or novel science. The difficulty we have is in working with this enumeration of biological diversity, it is essential that some of that enumeration is not novel and is not new science, other than covering new plants. It is actually the same techniques applied rigorously over more and more plants. It is my experience that this applying of the same rigorous techniques but for more and more plants without the element of novelty of technique

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DR F A BISBY

[Continued]

[Chairman *contd.*]

cannot compete with the pure science objective at SERC or at NERC. That is the basis of my suggestion that there should be a separate source.

934. Are you really saying that because some things which are novel are not always good and that which is good is not always novel, that the research councils are, in a sense, in their quest for novelty missing something which is good?

A. Yes but I am not criticising their standards. I believe that they are looking for a novel dimension, novel techniques and novel approaches and if a good monograph of one genus has been completed using a set of techniques and we wish to move on to applying the same technique to another group they will be saying, "But this is more of the same."

Lord Flowers

935. The decisions in research councils are taken by committees of people just like you, they are your peers?

A. With due respect, from the SERC from which I have received a number of grants, Professor Stace was on one of the committees recently, but it is my belief that there are no systematists on these committees today.

936. But the biology committee is made up of biologists like you—I did not mean they were systematists—and it is in the hands of the research community who appears on these committees. You may feel that it was not possible for you to fill the committee with systematists, nor was it, but nevertheless there has been a failure amongst the research community, has there not? They have got the wrong membership of the committee.

A. I agree with that, my Lord Chairman.

937. How does it feel to you as a working biologist? Do you feel completely powerless to influence that or are there things that you think you could do about it?

A. Well, my Lord Chairman, I am an optimist and will try very hard elsewhere if I cannot get the funds from the research councils but I included in my evidence to the Committee a copy of a letter from SERC about a recent application. I was devastated in receiving that letter. It would have been far better to receive a letter saying the grant proposal was inadequate but this letter refused the grant application on the grounds that it was a policy decision not to cover my topic.

938. Why is it that 100 systematists—if there are 100 in this country—do not write to the SERC and say, "This is monstrous that this sort of decision should be taken."

A. I am writing to the SERC and I shall say that but I am biding my time until my anger has receded.

939. Other people working in other subjects who feel their subject is neglected do do this and it does have an effect. I have wondered a lot during the course of this enquiry why the taxonomic community itself has not risen up in anger and done something about it.

A. I was going to say I think outside the institutions maybe the taxonomic profession is not that cohesive but that is not right as there are

cohesive actions from the Systematists Association and the Linnean Society.

940. Is it because it is orientated by the Natural History Museum and Kew to run part of this system?

A. No, because they do not call on the research councils for their funds, so it is a question for the others.

941. The research councils can say, "These people are doing it in a big way, why should we bother?"

A. They do say that sometimes, and I have answered that. A number of my projects have had contributions from funds at Kew or participants from Kew, and I have used that to answer them by saying, "Yes, we are doing it hand in hand with them".

Chairman

942. It does seem a little strange, looking at the letter you received from the Science and Engineering Research Council which said that, "The proposal did not involve any new experimentation or observations but rather its approach was clerical, encouraging consensus decisions" etc. It suggested to me that if you were to put up to the SERC now the notion for revising the whole international system of units of enormous importance throughout science you would be dismissed on the same grounds. Do you think that is true?

A. Yes, that phrase was the one that devastated me. The answer to it is, first of all, the project in question does have clerical work involved, and the application in question was not for the clerical work. If you had read the application you would have seen that the clerical work was being paid for by somebody else. Secondly, the chairman of that committee, for instance, is a molecular biologist—I have molecular biology laboratories next to me at the university and it is not clerical work but drudgery of the same sort which is going on in the molecular biology lab, no different from some of the clerical work involved in some of the databases themselves. I would agree with you that was the main fault in that criticism and the one that I shall challenge.

943. Are you saying the whole business of sequencing has now become so routine that it can be mistaken as clerical work?

A. I said in my evidence, my Lord Chairman, that I believed enumerating the species' diversity of the world to be as great in importance to mankind as enumerating the human genome. I sincerely believe this, and this idea of the unified central checklist which provides services to people who use biology is of enormous impact to mankind.

944. This suggests perhaps one ought to proceed as systematists in the same way as molecular biologists proceed in their pursuit of unravelling the human genome, namely, by massive international co-ordinated activity?

A. Yes, my Lord Chairman, and I am part of an initiative to put such proposals to the European Community over the course of the next month.

945. In a sense, when you come to answer one of the questions about who should pay, you are already pointing to the fact that perhaps there should be an

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DR F A BISBY

[Continued]

[Chairman *contd.*]

international contribution for any necessary work which is required for producing a catalogue of global diversity?

A. Yes and no, my Lord Chairman. Yes, the logic of it is that a lot of the global diversity should be organised from international funds. I can tell you this from my heart because I have tried it for my own legume system, of which I am a co-ordinator. The difficulty is that the funds at present do not exist at the international level for this type of activity. Secondly, when you do find those funds you are very likely to find that the United Kingdom is going to be putting more into them than it is taking out. Because of the international element there will be many poorer countries expecting to be helped along by these international funds. Whilst I believe the EEC is the real source I will be interested to see the calculation if we were to succeed as to whether or not the United Kingdom was gaining or losing from us obtaining these funds from the European Community.

946. In that connection it has been suggested that perhaps our role as overseas aid distributors through the ODA might be a suitable vehicle for us to give more practical aids to some of the less developed countries. In other words, that we would pay for work done here or done to help work in overseas countries in this particular field. Would you agree with that?

A. I absolutely agree with that, my Lord Chairman. I was at a meeting with the Department of the Environment which held a meeting on biological diversity about three weeks ago at which the ODA made a strong presentation and released a very interesting booklet which described their role in biological diversity work abroad.

Lord Porter of Luddenham

947. Earlier you said, "Never mind if I can't get it from the SERC, I go elsewhere", since we are talking about funding I just wanted to ask you where "elsewhere" was?

A. The main grants coming into my laboratory have so far been from SERC. If that is cut off it is a serious matter for me personally. I have obtained some funds from the EEC. The problem with the EEC is the problem in general of systematics, that many Director General offices in the EEC have a little interest in systematics but none of them have a lot. You can approach DGVI, XII or XIII and all of them will show some interest, the problem is to get substantial funds from them. Where else to go for funds? I have perhaps been unduly lucky that I have obtained some small funds from the United States Department of Agriculture in my laboratory; I have also obtained some funds with the information industry, which I think should not be overlooked, that is organisations such as BIOSIS and CAB which, in my opinion, are playing an important role in the provision of information and they do manage to generate some funds there, I believe not for profit, so some of those funds are re-invested in the information provision. Lastly, the United Nations' environment programme is the principal target.

948. Are you successful? Do you get significant funding?

A. My particular project is in a parlous state at the moment and I have not succeeded there.

Chairman

949. We have deflected you from your main train of thought for which I apologise. Would you like to continue?

A. What do you think should be the relationship between the leading systematic institutions and the universities? I should like to see a stronger series of partnerships. I think there should be partnerships and there are one or two, there is one between Kew and Reading University, but I would like to see these strengthened. Is systematic biology a discipline in its own right or merely a service? It definitely is a discipline in its own right. Just because I emphasised the service element does not mean that you should under-emphasise the scholarly element. Is research on a systematic collection an inseparable part of curating it? I am not really competent to answer that. It is not within my expertise. Question 7 is for me. One of your witnesses has suggested that this dichotomy, that is between evolutionary research and producing a reference system, is the basis of our malaise. I disagree with this, and this is the same thing. I think this dichotomy provides the most attractive feature of our discipline. It has the attraction of a pure science and the utility of technology at the same time. The fact there are these two aspects to it does not belittle it in either area.

950. Pausing there, because the sort of feeling one has had, and you have hinted at it yourself, is that there is what one might call the molecular biological aspect of the subject and the old systematists who have not been talking to one another, yet the way forward is obvious, so it seems to us, since genetic material ultimately is the determinant of what is expressed in the form of plant or animal, those two should go hand in hand, together with some computerised storage of information which you are yourself very keen on. Is that a correct interpretation?

A. It is correct. Let me say, at the EEC I was unsuccessful in one round of negotiations in DGXII. I was unsuccessful in persuading them to create, in the next framework, a programme of plant systematics. What they were willing to create within the framework programme was a niche for projects that would join together—molecular studies and taxonomic databases—with the view that it would be healthy for them to be interlinked.

951. At the end of the day it must be true (to refer to question 7 again which asks about the two strands of systematic research—evolutionary study, on a scholarly basis, and the development of a reference system) that you cannot have an evolutionary study on a scholarly basis without the elements—genetic basis and ultimate expression with classification?

A. I agree with that, my Lord Chairman. Let me just give you one other area where I feel strongly and that is that it is amazing how frequently, when one speaks to molecular biologists, they somehow believe one could do without the taxonomy altogether. We

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[Continued]

[Chairman *contd.*]

need just to remember two facts. One of them is that it is not yet possible to recreate an organism from DNA taken out of the refrigerator. While it may be interesting to store genes as DNA, there is no way that it is a substitute for our knowledge of either healthy seeds or plants. The second important fact for me came from a seminar I went to in Nancy in France on running molecular data bases, the data bases that hold information on proteins and DNA. The man in charge of the taxonomic entries on the database, said in his estimate 15 per cent of the entries in the molecular biology data bases are actually insecure because of uncertainty as to which organisms they apply to. I was astounded at the figure. I knew the figure was high but that it should be 15 per cent was extraordinary for me. Since I have met this man he has been a regular user of my own database, I should say, to try and solve his problem with legumes. Both of these facts relate to this interrelation. There has to be a healthy interrelation but no amount of molecular work will require the demise, as it were, of a species checklist of organisms as organised by taxonomists.

Chairman

952. Clearly the interrelationship between the two is bound to be faulty if in fact the competence in each of the two wings is inadequate?

A. Yes. And there is a problem of just understanding each other, my Lord Chairman.

953. Because the molecular biologist has no understanding of the classification of plants or animals you mean, and vice versa?

A. It is not as bad as that, my Lord Chairman, but they have little understanding of the functions of taxonomy and the taxonomist has little understanding for the functions of molecular biology.

954. They do not fully appreciate the power and the limits to the power of the methods they use. I am sorry, I interrupted you again.

A. Question 8, "You bemoan the shortage of funds for bioinformatics in the United Kingdom. Are things better overseas?" I can answer your question. I am confident they are better in the USA and in Australia. I wanted to mention what I have not seen elsewhere in this evidence. As well as the National Science Foundation's programmes in systematic biology, they also have a separate programme on database techniques in biology and behavioural science. It is the BBS programme, Biological and Behavioural Science.

955. Is that under the auspices of the National Science Foundation?

A. Yes. But the point is they have set up a special initiative. I do not know whether it is to run for one year or whether it will run for two or three, to support bioinformatics for biology. I am not sure what the behavioural equivalent of bioinformatics is, information technology for behavioural science, but it is a special programme with special understanding given to prototyping, testing and then the actual hard work of writing and developing software and computer systems.

956. May I ask in that context is it essential that there be a universal system of computerisation of the data or would it be possible to have several systems providing that they interconnect?

A. It is absolutely essential that there should not be any demand to make a universal system. That would be impossible for very many reasons, both practical and political. I am chairman of the IUBS working group on taxonomics and we are establishing standards for the exchange of data including the exchange of data formats which will allow different taxonomic databases to interconnect and thus get over the problems of institutional pride over particular hardware and software.

Earl of Cranbrook

957. Are there any limits that the hardware imposes on such aspirations?

A. No. The development of taxonomy data is so much slower and more arduous than the development of technology. Our problem is that we cannot keep up. At any point the life span of any major taxonomic project is going to be 5, 10 or 15 years. The technology has improved so very rapidly at any one moment we are always behind the technology. I think it is the reverse and technology is not ahead of us. Can I say on that point that was my answer to your question. Australia also is a good example. If you think of Australia as a continent, it is the first continent to have a computerised checklist of its plants, computerised, which you can have on disc or printout. They have a complete checklist of all the synonyms of all the plants. It is a major achievement. I also want to say reading through this evidence here, I repeat my comment about the spectacular underinvestment in Britain on bioinformatics, on information technology. I was distressed that many of the other people who answered the question on information technology answered it giving cladistics, which is an excellent area of investigation, but in a quantitative sense the largest use of information technology in systematics has to be in processing the information for users to use.

Chairman

958. May I say at this stage that we are having great difficulty in getting any hard data about the amount of money that is spent in this field globally, let alone in any sub divisions. You speak as if you were able to make a comparison between what is spent on bioinformatics in this country and, let us say, comparable countries. If that is so, could you let us have them?

A. I do not have precise figures at my finger tips, my Lord Chairman. But I repeat I am confident that the funds in the United States and in Australia must have been of an order of magnitude larger than are available here. The funds available are substantially larger than ours in some other countries of the same size but there I am on uncertain ground. I would take the example of Geneva and the Botanical Garden in Geneva. I think the funds do not come from the state but come from the City of Geneva. The Swiss equivalent of Kew has made a very good investment

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[Continued

[Chairman *contd.*]

in its information system and it would be good to see something similar in this country.

959. You will understand that unless there is hard information we will not be able to “butter our parsnips”, as they say.

A. If I am able to help and provide information after this session I would be happy to do so.

960. If you could find some information which was reliable of these amounts that would be very helpful.

A. I am sure that it is possible to get some information both on the investment in bioinformatics that must have taken place in Australia and a friend of mine in Washington will tell me the size of the BBS data programme at NSF, the computer programme.

Chairman] If you could let the Clerk know, thank you. If we can go on. You make a very surprising statement which we must not leave un-discussed with is that the Natural History Museum should be split into two parts –

Lord Flowers

961. Before you begin to answer that question do you mean in the physical sense of splitting it into two separate buildings or merely the financial responsibility for paying for the two kinds of activity?

A. Let me say that the most important part is in the financial and responsibility sense but I also did mean it secondarily in the physical sense. Let us deal with the responsibility side. You appear to have been tussling with the question as to whether the OAL or DES is the appropriate source of responsibility for the Natural History Museum. It seems clear to me that there is a genuine public entertainment function. There is also the world's greatest systematics institute there—not a science institute but a systematics institute—known all over the world with an enormous responsibility. They are presently in one institution under one roof under one director. I believe you will have difficulty in solving the problem either by putting the whole of that institution under the OAL or DES. There are two different functions. It seems also to me that the IPMS evidence was the same. It really would be very difficult to have one institution under two masters. That led me to the logical conclusion that we have two institutions and that it should be separated into two institutions, one calling on the funds from the OAL and the other responsible directly to the DES, if I might say so, not saying it is science but calling itself systematics. It is the nation's, if not the world's, greatest systematics institution. If you have two institutions are they under one roof or do they separate? It is my understanding the beautiful building they are in at the moment costs £6 million a year to maintain. It is on a prime site in the middle of London. It occurs to me that that need not necessarily be the case given the way we have talked about education. I know of some other systematic institutes and I know of one, for instance, which Professor Chaloner will know about, which has moved to a university campus so that it can exist and be at an education centre.

Chairman

962. You will appreciate the magnitude of the change which you are wishing to see brought about also will constitute, for perfectly normal political reasons, the cause of the delay of any effective decisions to deal with the current and urgent problems you have expressed to us. Perhaps it is not necessarily the best way forward. Are you aware of the fact that since 1987 the scientific work of the museum staff can, of course, be supported by grants from the research councils?

A. I am although I am also aware that the research councils have stated fairly clearly that they are not intending to become major supporters of that work. I recently applied for a post at the Natural History Museum and I was investigating this question myself, and I spoke both to people at the museum and to people at the research council, and basically they were saying in rather exceptional circumstances they would support the work there, but they gave the impression that it was not their plan to be major supporters of systematics at the Natural History Museum or at Kew.

963. In terms not only of your own direct experience in wanting to advance systematics as a university researcher, but also the NHM itself is not likely to get any support from the Advisory Board on Research Councils or any research councils for systematics research, is that what you are saying?

A. Yes, I am saying that.

964. The core funding for this has to come from the prime funder of the Natural History Museum, which at present is the Office of Arts and Libraries?

A. Yes.

965. Do you think that is an unsatisfactory body?

A. I am going on experience of recent events, my Lord Chairman, which leads me to believe that it is unsatisfactory. I believe it is a matter of priorities. Although I am not an expert on the priorities of the OAL my belief is that they are basically different from those of the systematics of biodiversity for the world.

Lord Flowers

966. You have said something which I believe is quite important about asking questions of the Natural History Museum, and asking questions of the research councils about whether they would support work at the Natural History Museum. When we ask questions like that they say, “Yes, of course, we would be judged in competition with other things, but in principle we would.” ABRC have told us that is the case. You are saying it is only in very exceptional circumstances that it would be the case?

A. Yes.

Lord Flowers

967. That is a rather different story. I think it would help us greatly to have hard evidence that what you have just said is indeed the case. Not that I am doubting you in any way, but we need hard evidence so that it cannot be put by on one side.

Lord Butterworth] Would it be possible from some source to get the submissions that have been made

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[Lord Flowers *contd.*]

and the responses that have come over the last three or four years?

Chairman] The submissions to the research council?

Lord Butterworth] Yes.

Lord Flowers] They can always say, "That was a matter of our judgment of quality".

Lord Butterworth] If you looked at it over a period you might detect a trend.

Chairman

968. That is something we must discuss between ourselves. If you could just answer Lord Flowers' question.

A. The first thing is, when I spoke to some people at the Natural History Museum I was speaking to some senior managers there and was asking them about the opportunities from the research council and they told me that they had been in discussion or correspondence with them and had gained the impression that there could be some provision from there, but certainly not a major provision. We have already mentioned the view taken by SERC on some of my own work which is, far from supporting the part of it that was working with Kew, that we should be getting part of it paid for from Kew. I had a visitation from the biology committee in my lab at the beginning of the ILDIS project and the fund provided by SERC was a notional 50 per cent. of the start-up funds. When they came to my laboratory they questioned me very hard as to where the other 50 per cent. was going to come from. They really wanted to know very strongly that I was getting some support from within Kew. It was not core funds from Kew but a trust fund which related to Kew. That again is evidence that they are expecting funds to come into systematics from those institutions to assist their projects, rather than that their projects might put funds into them.

Lord Porter of Luddenham

969. We have rather skated over your specific mention of Swindon. I suspect I know the reason for that. It is not the first place I would have thought of attracting systematists. Secondly, I would have thought you might have suggested Southampton. Am I right in supposing you have told us that DES does not fund the NHM very generously, nor does it fund the universities, but it is well known to fund its own institutes?

A. I wished now I had not suggested Swindon. The thought was simply that NERC and SERC had their own headquarters there. I felt the possibility of a fresh start, rather than being in a university or in Kew or in a museum, could be symbolic and helpful.

970. You really feel that would be better for systematics or, indeed, any other branch of science associated with the university?

A. No, I regret the suggestion of Swindon.

Chairman

971. I think we have covered most of the questions, but let us work through to see if there is anything else you want to say. We have covered the

international dimension both as far as Europe is concerned, North America, the role of the ODA and so forth. Is there anything you want to add to that?

A. The one area I did not have a chance to mention was question 9 about the idea of international agreement or a reference system. This is an area where my own ideas are controversial and possibly different from other people's, but I personally think it is possible and essential that many of the users of systematics, international agencies in conservation, pharmaceuticals and agriculture are crying out for a simple reference system. They say, "How can I produce this when it is a subjective matter—taxonomy?" The answer is, I really believe there should be some decoupling between the genuine and necessary debate amongst taxonomists as to which is the best classification, which is and is not the route of evolution, and the synthesis of some slightly stabilised reference system which could be set in place for a five or ten year period for people to use and then revised as opinion changed. I believe that the computer information systems could be made to be part of such a process.

972. You mean these would be temporary, imperfect but useable keys?

A. Not even keys, synonymised checklists of the species. If you think of a computer information system about biology, the core part of species diversity is the species checklist. I can give two examples: take the international board for plant genetic resources in Rome, they receive information on the holding of germplasm collections all over the world. They try and form a centralised catalogue of these but for good reasons, that you and I know of, each of these centres use a different taxonomy for the same organisms. They would use our system to collate these into a central list but still allow you to decode it into local names for use at the different centres. The same thing happens at the World Conservation Monitoring Centre. The same thing is a problem for CITES, for the control in export and import of plants. There are many examples where the utility of a single registry, even if imperfect, would greatly enhance the image of our science.

973. Enhance the utility in different parts of the world with the knowledge we have?

A. Absolutely, my Lord Chairman.

974. Is there anything you would want to say about the starvation of systematic research by the research councils, which is presumably something on which you might have something to say in addition to what you have already said?

A. There is only one thing. One of the fears of the research councils is that there is probably an infinity of good taxonomic projects you could propose. Also, because taxonomists tend to revise classification, it is difficult even to point to a particular group and say the job has been done and finished. So coming back to our previous conversation about a world reference system, the existence of such a cooperative system worldwide would enable one to point out which groups are in a parlous state, which groups appear to be well covered or satisfactory at the moment so that you did not foster the view that some groups are being worked many times and also the view that there

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[Chairman *contd.*]

is an infinity of new projects that could be proposed. The SERC, for instance, would be far more responsive if there was some agency that could say, "These are a top priority group because this and this had been done, and, no, this can be looked at in another 20 years." This would assist in focusing on what we need to do.

975. In terms of the share of resources that systematics research gets, the chance of increasing the amount would have to depend upon the answer to the difficult question given there is a limit to the amount of resources that we can spend, which is set by government, what is the urgency of doing this work? Does it matter whether something is done 10 or 20 years from now? What is the current particular urgency as seen from your point of view or your colleagues in the field?

A. There are two elements. The first urgency is, of course, the conservation problem and the loss of diversity. This fact could be useful to us. The second priority is, if you like, a frustration at the waste of resources as I believe there are resources being wasted.

976. Do you mean financial resources?

A. No, I mean manpower resources. Because a centralised system is not available and delivered to people, many organisations are having to do their

own job. We talked about the world conservation monitoring centre, and of the IBPGR in Rome. At the moment no central system is available and organisations such as these are having to employ their own taxonomic assistance and doing, sometimes a poor job on their own, to make the best of the taxonomy themselves. Thus replication is occurring and a diversity of systems results, which is unnecessary and a waste of resources. The third thing is that some of the users who are really desperate will then come to inadequate sources. This is a difficulty in the agricultural area. There are people producing what some people would describe as work that is not critical to get a quick, dirty answer to those questions. It would be better to do the job well once rather than doing it badly several times.

977. Thank you very much. Are there any other points which we have failed to elicit from you which you would like to make as we draw this to a conclusion?

A. I think not, my Lord Chairman.

Chairman] If not, thank you very much for coming. My apologies for referring to you once or twice as coming from Reading. You will understand that to anybody coming from Yorkshire anything south of the River Trent is of little significance!

Memorandum by Professor May

Dear Dr Walters

This is a rather informal response to your letter of 8 March, asking for comments relevant to the terms of reference of the Select Committee on Science and Technology's enquiry into research in systematic biology.

I have associations with various organisations which will, I believe, be submitting more formal evidence to you. But I thought it might be useful to take this opportunity to offer some more personal views on one or two particular issues.

First, what is the "right" level of support for research in taxonomy and systematics in the United Kingdom (broadly, your questions iii and v)? On the one hand, I believe that Britain possibly does more than its share, relative to other countries. On the other hand, I strongly believe we should do more, for two reasons. Very generally, and for historical reasons I do not fully understand, there is a centuries-deep tradition of spending much more time and effort on research in the physical sciences—on the further reaches of space and the interior of the atom—than on identifying and understanding the living things we share the world with: Linnaeus' pioneering codification of the diversity of life on earth came a full century after Newton, and this legacy lingers. I believe that were we to start afresh, and assign resources among the sciences on the basis of an objective appraisal of their relative importances, systematics would be much more heavily supported at present. More particularly, Britain is disproportionately strong in many areas of science; but our imperial past gives us special strengths, special opportunities, and I believe special obligations, in taxonomy and systematics. There are very few other areas of science where our "comparative advantage"—deriving from past history—is more marked. Taxonomy and systematics, moreover, by the nature of the work contains more in the way of "inertial effects" than, say, nuclear physics (if you have not got the collections, you cannot create them quickly), which makes both our comparative advantage and our special obligation rather different than in otherwise similar, but less "inertial", areas of science.

Second, I see a need for more quantification and comparative analysis of the broad claims made in the preceding paragraph. I believe the Standing Committee should press for quantitative information about absolute levels and trends in research support, training, and other aspects of systematics. It would be helpful to have an analytic compilation of instances where important work languishes for lack of adequate basic information of a taxonomic/systematic kind.

Third (relating to vii) I think it would be demoralising to have the NHM turn around, and go from OAL to DES. But it does need to be recognised that the NHM is qualitatively different from all the other museums that are lumped under this umbrella. The science museum, and the various art museums, all obviously have significant research components. But their primary function is in each case the conservation, interpretation, understanding and display of objects. While this is also a large part of the function of the NHM, it differs in

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also having a major responsibility as essentially the research institute for taxonomy and systematics—with all that that implies—in Britain. I believe this makes the NHM qualitatively different from the other museums, and I am not clear that this difference is always fully understood.

Fourth, you will be aware that Britain is not unique in having worries about whether current support for systematics is adequate, in the light of current basic and applied needs for its undergirding research in biodiversity, climate change, and so on. The Smithsonian Institution (on whose overall Advisory Council I continue to serve) has just set in train a study of the state of taxonomy and systematics in the USA. The Select Committee might find it useful to be in touch with Robert Hofman (Scientific Program Director, Marine Mammal Commission, 1625 Eye Street, NW, Washington DC 20006, USA), who is coordinating this US study.

I hope you find these comments helpful.

Yours sincerely

Robert M. May

19 March 1991

Examination of witness

Professor R M MAY, Department of Zoology, University of Oxford, called in and examined.

Chairman

978. Good morning, Professor May. Thank you very much for coming. You have had a list of questions which we wanted to put to you and Dr Bisby. They are not, of course, exclusive and others may arise round the table. We have had your letter and this has been circulated to everybody. Is there anything you would like to say by way of a general statement at the beginning or any particular additional observations you would like to bring to our attention?

(*Professor May*) There are two things I think I should emphasise. Firstly, many of the things you want to ask me about I am quite ignorant about. I am not a taxonomist and I am not a systematist and I am not nearly as knowledgeable about the way funding things are managed in this country as maybe I will be in another few years. Secondly, in addition to the set of questions you have offered to me I would briefly like to pursue with you—and I even have a handout—some very crude and imperfect initiatives that I have started with some of the people at the Museum to try and quantify some of the claims which have been given without supporting numbers in your 202 pages of public testimony and to draw your attention, I am sure unnecessarily, to one or two other factual questions which I think would be helpful to have resolved. Just from listening, for example, it is my impression—and I did not bring these sort of numbers with me—that the Natural History Museum has done not badly with the research councils. I think there is in particular one major grant that went to a group of people studying plankton diversity. I do know that is a factual question, with respect, but the concern is that many of the statements you have had have been unsubstantiated statements which could be substantiated or not—

979. Could I just interrupt you here. If you have any objective evidence on those facts which you could put before us, it would be helpful.

A. I am going to share with you some very crude figures for taxonomy in the United Kingdom, compared with the United States and Australia. I would suggest it would be a good idea if some people

could get some information about the age profile in the discipline, if you are not already doing that, of taxonomists as compared with some controlled group like other biologists or chemists. You would share with me at least one anecdotal impression of the Linnean Society meeting at the Royal Society we had last week. It was a showcase to users of taxonomy which was held in the Royal Society and which was quite extraordinary and quite different to any other I have attended in the age composition of the audience; essentially there were no younger people. I do not know why there are no younger people in the discipline. That was an impressionistic snapshot and to flesh out and define what you mean by the personnel we are encouraging in the enterprise of systematics and taxonomy, we need to find a couple of reasonably controlled groups to find out if indeed it is true that the discipline has this over-aged structure.

980. Yes indeed, we will pursue that. I did mention at that meeting there was a questionnaire but it does not touch on age distribution. Perhaps you would make some suggestions about the way in which that might be tackled. Would you like to go on with the questions. Are there any points you would like to bring to our attention or shall we just work through them. There was one point in your letter that struck me as of interest. You made a great plea for starting afresh and assessing resources on the basis of an objective appraisal of their relative importances. Is that not a very difficult thing to do?

A. It certainly is.

981. When a subject might be said to be in decline and given the way in which scientists will defend their particular corners come what may?

A. I think it is very difficult. I realise one can only work at the margin of the pattern one has but in fact I do have a little hand out. Why do I not hand it out because the first page consists of a reiteration of what I thought was important; namely as one talks about taxonomy and systematics one must ask what is it that makes it specially important? What is it that distinguishes it? I can make a case for the fascination of any field of human enquiry but what are the special features of this?

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PROFESSOR R M MAY

[Continued]

[Chairman *contd.*]

982. Perhaps if you could refer to the points you want to make and that could be given to us later.

A. The first point I would make—I do not want to go on and on about it—but for curious reasons lost in the mists of time and ill-understood, Linnaeus comes a century after Newton, and the idea of quantifying the diversity of living things is something that came later in the stream of human enquiries. I think that is at least partly responsible for the fact that we are accustomed to “big science” and “little science” in ways to my mind, which are not necessarily a dispassionate reflection of what are the major needs of our time which are a curious mixture of that and past patterns. I will amplify this in some of the other questions, but I do think that taxonomy and systematics, both as a subject and an interest in itself and as a basis for other studies, really does need an injection of more money than it has. One only has to point, as I guess you were just discussing, to the fact that there is, for example, amazingly no central computer catalogue of the million/two million species that have been named. There are not even decent computer catalogues of most of the major groups, which is an astonishing statement partly about the people in the discipline and partly about the funding patterns. The initiatives to try and get these things done are hampered by the fact that it seems, within the traditions of that discipline, to ask for £10m for an international enterprise is a huge sum of money; whereas I would not think of it myself that way, against the traditions I grew up with.

983. How is one to raise that if you are to be followed in this argument?

A. I would have thought (and people round this table would know better than I do) that is what ABRC is partly constituted to do. I recognise the difficulty in the nature of human institutions, the ABRC is a bunch of people sitting round a table largely chosen from the disciplines that currently are in good health. It is not easy to do and you have more wisdom on this than I do.

984. First, one has to convince them, of course, that some affirmative action is necessary against the background of the fact the community itself could, in some senses, be held responsible for what decline has taken place, but they have not. They have allowed the new stuff to drive out the old and necessary, if you like, to a certain extent. That is not really a good wicket from which to bat initially, is it?

A. I think that is true.

985. Are you looking to a report from this body, shall we say, to highlight the problem?

A. I do think that the discipline itself contains unwittingly its own worst enemies. Even at the meeting we were both at the other day, the fact that people are still, in the midst of what is meant to be a showcase of the needs of the subject, apt to go off and digress into religious warfare about cladistics and so on is not helpful. At the same time I would hope that there is a group of aggressive younger and older people in this discipline; that the new excitement injected by molecular techniques is an independent way of approaching old questions; and that there is a new excitement injected by the comparative method of studying evolutionary questions, and more

sophisticated statistical comparative tests of cross-groups testing for phylogenetic correlations, which gives you a new and exciting tool for exploring old questions. When you put those fundamental, intellectual advances together with the apparent needs that are created by the disappearance of the tropical rainforests and climate change, there is a group of people making a persuasive case. It needs, in my view, groups like this one and like the committee that John Krebs is chairing for initiatives in NERC, and other things, to simply try and make this case. I would hope at the margin, not in a revolutionary way, but in an evolutionary way, one might see changes with more money coming into the discipline from the research councils.

986. Who is to capture the minds of the young people who are going to be the leaders of the future? We have been told, and you may have heard the evidence of Dr Bisby, that there has been a very real paucity of teaching in the universities of this subject, and it too has declined. We were not given precise figures.

A. As you know, Mike Claridge is trying to put together some more precise figures about that. Anticipating one of the other questions on the list you are going to ask me, I translate the term “biodiversity” in the broader sense to embrace things other than on a taxonomic systematic base. I hope that there will be an increasing number of brighter people attracted into this general subject, and this does not depend simply on there being more in the way of attractive courses in taxonomy and systematics in the narrow sense. Nor is the picture as uniformly bleak in my mind as is sometimes painted. The chap who would have been the best candidate for the demonstratorship of ecology at Oxford last year in fact is in the Natural History Museum by choice, because that is where he would like to be, it is what he thinks is more exciting, and he is there with money that was created by some of the controversial things that Neil Chalmers did. I have a more up-beat view than some of the witnesses.

Lord Porter of Luddenham

987. It has been represented to us that the Royal Society is not entirely blameless in this matter and does not represent systematics in its elections and so forth. As a Royal Society professor you have some influence there. Do you feel that is true, that there are strong cases for election but because they are in that field they are not properly considered?

A. I feel embarrassed responding to a question like that from you because you know so much more about it.

988. No, you know about the systematics side.

A. My impression would be that of course there are fashions and spheres of influence that wax and wane in electing people to the Royal Society. I can think of one example, without naming a name, of someone I would have thought was a strong candidate who did not do well last year, but I think that had nothing to do with anything other than just a particular personality.

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[Continued]

[Lord Porter of Luddenham *contd.*]

989. You do not see a long waiting list of people of higher quality, if one can make these judgments, in systematics than in the other side?

A. No.

Lord Flowers

990. If there are not people of sufficient quality to be elected as members of the Royal Society in this subject does that mean the subject is in some sense less intellectually demanding or rundown? What does one conclude?

A. I would have said Alan Wilson—I would define him essentially to be a taxonomist systematist even though he uses molecular techniques—he is a very controversial character and he was elected the first or second year he was put up recently. It may be that on the botanical side, which I do not know so well, there is a candidate at the moment whose progress will be interesting, and I would expect that to go reasonably smoothly. I think the fact there are not too many people elected to the Royal Society reflects the fact that it is a field that never did have lots of people, as we will see with some of the numbers. It is not clear to me, and I am embarrassed a little bit with this discussion because there are people round the table who are better qualified to speak than myself.

Chairman

991. Perhaps we should take this opportunity to turn to another suggestion which you make which bears on the centrality of the Natural History Museum in this whole enterprise. In your letter you make a suggestion that it should be regarded as the essential research institute for taxonomy and systematics and in that way it differs from the other museums and galleries which are national and funded by the Office of Arts and Libraries. What do you think should be done, because you do not suggest it should be detached from the Office of Arts and Libraries? You say it would be demoralising to have yet another change, I imagine because too many changes, too often are demoralising.

A. I am not at all enthusiastic about having one more round of trauma. I do believe that it is different in character from all the other museums in that, whilst of course there is a research dimension at the V&A, the National Gallery and the Museum of Science of Technology, in none of them is it as massive. You have heard from many people that the Natural History Museum is *the* major institution for taxonomy and systematics in the country, possibly in the world, and it happens to be conflated with the museum in a way that I think in the best of all possible worlds is good for everyone. Nonetheless, it does mean I am not so keen on suggestions, for example, that the museum band together with other museums to make a case for money for museums, because I am not at all sure in a world of finite resources I would wish to be all that more generous with the other museums.

992. Do you feel that the NHM is under-funded with regard to the research activity it ought to be undertaking on its core funding?

A. In two respects yes. The first in this ideal dream world that one would wish to move towards in an

evolutionary way I think the importance of the subject is such that we wish to see it funded more. But quite apart from that, even given the realities that we live with, there is the fact that the core funding has not kept pace with the inflation of salaries (so that one round of cuts managed to reduce salaries to around 91 per cent of the core funding, yet three years later one is back to the position where more than 100 per cent of the core funding is going to be taken up with salaries, setting aside the buildings and things like that. That is something that the universities have been living with for a long time but it came as rather a shock to the Museum which in some ways had been, relative to the universities, somewhat isolated from that. These trends are nonetheless, to my mind, unfortunate, given the importance of the subject which I think does make it unusual. I would wish to see the core funding in research enterprises match real inflation and preferably run a bit ahead of it. The justification I give for that is not comparing it with universities, nor saying that it is a natural right, but the special importance and interest and our special responsibility in this particular subject.

993. Because of the international importance of the collections?

A. Yes.

994. That we have them and they have to be looked after properly and used?

A. That is right. The four-fold argument that I should more logically have taken your invitation to spell out at the beginning. Firstly, to identify that this whole subject has a historical pattern in every country of underfunding because we came to be interested in other animals in the world later than we came to be interested in the nucleus and the heavens. Secondly—this is one of the questions you are perhaps going to pursue—because it is in the nature of this subject that it is collection-based. I think that is true even for the more molecular developments in the subject. They still really do need to be based on collections which means that a new player finds it hard to enter the game; if the Japanese were to decide to make this their special responsibility,—they could not become a major player as quickly as they did, for example, in plasma physics because the lag is more than a generation to train a group of people. The subject has an inertia derived from collections with origins a century or more ago. That is the second reason; I think the subject is rather special and rather different from other areas of science. Thirdly, there is a peculiar thing that again comes to my mind, that gives us a different kind of responsibility from that which we have in other areas of science—by “us” I mean the first world—that most of the subject matter we are talking about is in the third world but yet the research enterprise is in the first world. That gives it a curious sort of status, too, that must enter when one asks what is the relevant investment and so on. Fourthly and finally, the argument you have heard many times, is that, unlike many other areas of science, systematics and taxonomy is an area where the things we are talking about are disappearing as we talk. To my mind one of the major reasons for being interested in them now as a matter of urgency is so that we have a more rational grasp of a world where things are disappearing, so that we can have a

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[Continued]

[Chairman *contd.*]

synoptics catalogue of what is there not just a taxonomic catalogue of what is there for particular research interests in taxonomy *per se*, but a useful catalogue of what is there with information for conservation and ecology, what are the distributions, what has endangered status, so that beyond that one can do both the fundamental research and apply things and make the kind of rational choices that Ghilleen Prances pioneered in looking at Amazonian plants.

995. Perhaps if I can sum that up and you can correct me if I am wrong. You think now is the time for what one might call special affirmative initiative in this particular field and that without it neither the community itself can be restored to the health which it patently has not got at the moment nor can we discharge our responsibility nor can we do our work for the third world adequately and we take the points about inertia which you have mentioned. Can I ask where you think that money is to come from?

A. Going back again, my Lord Chairman, I make no claim to speak with any usefulness here because I do not understand the system here well enough. I would have thought the appropriate thing would in the first place be evolutionary increases in funding from the research councils, and also from the OAL to have a more stable funding pattern that meets the real cost of inflation.

996. With your recent experience in the United States have you got any direct knowledge of the NSF initiatives in this area?

A. I do not have any real knowledge of the NSF initiatives. What I do know is that the same sort of problems occur in the United States. If people think the Natural History Museum has problems they ought to have some broader sense of the problems that The Smithsonian Institution has.

997. Do you feel we could learn something from them?

A. I think we could learn something from them. It is always helpful to know what other people are doing. I think it would be useful also to learn what is happening in Australia, being a small country where it is somewhat easier to document the workforce and what is going on, and also a country which in some interesting ways is a mixture of first and third world. I do not mean that socially so much, but it has a fauna which is still not as well-known as the British one but is much better known than the tropical one. It does seem to me that Australia invests per capita more heavily in systematics and taxonomy than the United States or Britain, whereas (as best as I can estimate—and it is a very, very rough estimate) investment in taxonomy and systematics in Britain is comparable to that of the United States.

Lord Walton of Detchant

998. Some of the other witnesses have suggested, following up the point that you made, that there should a separate and newly established funding body, perhaps funded through the ABRC in order to preserve and protect funding for this discipline. Of course the size of discipline does not compare with the disciplines that each have their own research councils. The alternative proposal that has been

made in certain quarters is there should be earmarked funding within the budgets of two of the research councils, namely SERC and NERC, to protect this field. What is your view about those alternative proposals?

A. I am not sure that my view is worth having. I have an inherent prejudice against inflexible earmarked funding. But I do not have a prejudice against broad direction of research. If that sounds woolly-minded maybe it is. I do not like really crisp, ring-fenced funds that are going to sit there for all time. My preference would be to have what I understand the NERC is moving towards in a modest way, which are initiatives that direct money broadly in a particular direction; but, as I say, I am uncomfortable in this sort of question because I am not sure my opinion is worth having.

Lord Flowers.

999. Can I ask a related but different question. Whether one likes it or not the Natural History Museum is a fairly inflexible object. If one can find a way of persuading it to work to some extent in a different fashion and to have it differently funded that might be easier than doing conceptually better things. The Natural History Museum is next to Imperial College, which you know quite well, and which is nowadays reasonably good for biology. Also they are talking together a little bit these days. Do you think it would be worthwhile trying to persuade the two institutions to set up a joint venture, unit, group—call it what you will—that will use the academic brilliance of Imperial College and the great expertise and the collections of the Natural History Museum to do genuinely joint work; it is almost on the same site after all. If this could be funded properly for a period of ten years, let us say, they would then, one would hope, change the whole perception of the activities in such a way that others would follow—not take it over but give leadership?

A. I think it is a splendid idea. I think it is a question of the scale of that which is feasible.

1000. I think it would help us if you could put your mind to that for the moment and say what sort of scale might be necessary?

A. I think the current initiative which the museum and Imperial have (apart from already having made a joint appointment in geology and looking to make some sort of joint appointment in work in biodiversity) is a modest linking but nice. It would mean that somebody who had money and support coming both from Imperial and from the museum might have a lab in the museum but students at Imperial. The initiative is to try and get ideally somebody really good in molecular evolution, an Alan Wilson sort of person, base them in the museum, raise outside money, talking a modest scale but not trivial, millions of pounds from the development trust at the museum to build the lab and attract a good person, but have the person also a Professor of Imperial, teaching at Imperial with graduate students at Imperial. That to my mind, is a very exciting initiative. It is an initiative which aims to get molecular evolution in a real sense as distinct from molecular taxonomy. It is still more modest than I think you have in mind.

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[Continued]

[Lord Flowers. *contd.*]

1001. If you had a few million pounds to spend that would be the best way to spend it, raising activity in this country?

A. It may not be the way that best serves the sorts of things the committee is talking about, or my own personal interest in having a computerised list that I could do so many things with if it existed. But I think for a combination of exciting science—something that is likely to capture the imagination of undergraduates—and feasibility in an evolutionary funding pattern, that seems to me a very sensible sort of initiative. It is something that Walter Bodmer, as the Chairman of the Trustees, is very enthusiastic about.

Chairman

1002. In order for it to be effective, would it not need to achieve a pervasion of these ideas to other institutions, if there was to be an uplift in the attitude in other universities' biology departments and, therefore, would it not be necessary to have such an institute really being willing to have guest workers on secondment for considerable periods and co-operative enterprises with other universities?

A. Yes, I would hope that is so. The museum in a modest way does have that. For example, this student that I mentioned earlier—it is only one person but at the end of the day the transformation is the sum of single excellent people—he is jointly between myself and the Natural History Museum, in London.

1003. The Museum is working with you jointly?

A. Yes, exactly.

Lord Porter of Luddenham

1004. Why did you so categorically base them in the museum when talking about the senior appointment?

A. I did not mean to say it categorically. That was just what the thinking was for this particular person.

1005. I am just wondering how you feel, if there were a centre as Lord Flowers suggested, where would the centre's home be?

A. I have no firm view about that.

Lord Flowers] I should declare an interest, I have mild connection with Imperial College, in case my question was misunderstood.

Chairman

1006. Some would argue that perhaps on the botanical side there is already a working relationship between the Royal Botanic Garden at Kew and Reading, for example. Would you want to see both the botanical and zoological elements in the same institution, or would you want to allow normal evolutionary development which might produce more than one centre?

A. Again, it is not something I have a view on. Insofar as I do, I hope for as many different things as you can think of.

1007. We all want the most, the greatest variety, but it would be limited by money at the end, would it not?

A. If you turn to the United States for a moment, the Smithsonian (I also have an association and am on the Board of Advisors at the Smithsonian) has been very poor in my opinion in not exploiting the natural interactions it ought to have with Maryland. Its links with Maryland, although they have formally been there, are in fact less real than those between Imperial and Natural History Museum and do not seem to me to be going as well as ours. It is a very generic problem. If you look at the university museums in North America, which were once flourishing institutions, where you had on-campus quite major museums, the vision we have of the age of dinosaurs, a cononical entity in the museum, is given to us partly by Charles Knight and partly by the mural in the Peabody Museum in Yale. University museums are at the forefront of what went on a century ago. Their story today is very sad. Princeton essentially gave away its collection. The Peabody Museum at Yale has had a long running disaster story. The Museum at Harvard is a more mixed story. I do not think it can really be claimed to be a flourishing institution of taxonomy and systematics wedded to intellectual enterprise.

1008. Do you want to generalise this and say that universities on the whole are unfit to run museums of this importance?

A. For the set of reasons other people are talking with you about, it is difficult to do. Michigan is a mixed story and Berkeley, to my mind, is the one real success still. I tend to attribute it to personalities in that case.

Lord Flowers

1009. Universities that ran a good museum would be regarded as a museum piece

A. Except Berkeley does it.

Lord Porter of Luddenham

1010. The ideal would be that you would retain an independent museum, administered by the Natural History Museum but with the research arm very closely attached to the university?

A. I think that is so much the right idea. At the end of the day the way you attract good young people into the subject is by having people who are excited about it in contact with them. That is hard if they are not meeting them as undergraduates.

Chairman

1011. Such an initiative cannot go on indefinitely, because it could be argued that if it was necessary indefinitely the community was in a state of permanent ill health. Therefore, it is something which can be tried for a limited period, in the course of which one hopes that the subject will be restored to its rightful position within the general field of biology and then would be able to stand on its own feet. Would you agree that the initiative should be of limited duration?

A. No, I would think it would be desirable that museums have a continuing engagement with universities.

1012. Yes, but I mean injection of any extra funds.

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[Continued]

[Chairman *contd.*]

A. Yes, I am sorry.

1013. You would think it was not necessary to go on indefinitely?

A. I do not have a view on that.

Lord Walton of Detchant

1014. Could I say that in my own field of medicine when it was perfectly clear that nationally there was a shortage of clinical scientists engaged in research in clinical studies in medicine the Wellcome Trust, for example, established a series of competitive senior research fellowships in clinical science which individual departments could compete for, sometimes on a joint basis between a hospital and university department, in order to get an opportunity to engage in research on a 5-8 year basis as a kind of pump-priming exercise. Later they went even further by establishing 5-8 year senior lectureships in underprivileged specialities which again were competitive. It is not impossible if an appropriate funding source can be found that in systematic biology you might get a joint project put up between a university and a museum to establish this kind of appointment. Do you think this would be a helpful initiative? If so, can you identify a potential funding source?

A. I am a bloody-minded sort of character and I think having things competitive is always a good idea. But it is not easy to see who will fund initiatives of the kind you envision in this discipline in comparison with the biomedical sciences, and particularly in this country where there are so few charitable trusts and so on. Nor is it easy in the United States to identify foundations who wish to embrace this sort of thing.

Chairman

1015. I look round at my colleagues and I do not think we have any more questions to put to you, Professor May. Have we failed to cover any points that you would have wished to have covered?

A. Yes. I would like to ram down your throats a very imperfect attempt at an assessment of the scale of the enterprise. Paying due attention to the exigencies of the stenographic scene, let me convey a rough verbal sense, but then I will leave with you some simple pages. I carried out these estimates with Kevin Gaston, who is the person I referred to earlier who is at the Museum, a bright young lad. One of the things I asked was how are ecologists in general distributed among the countries of the world? How are the taxonomists distributed among the countries of the world? That is an easier question to ask than to answer. For ecologists what I did is take a study that was done by the NSF in the mid eighties which took one year of biological abstracts and picked all the computerised abstracts under the heading of "Ecologists" and then looked at the country of origin of the author. That is a sample size of 16,000 and a rough measure. For systematists we looked over 5 years, 1986-1991, at the people who borrowed from the insect collections of the British Museum. That is obviously an extremely imperfect and biased sample. It is going to be biased to the old world rather than the new world because their holdings are better held,

and the old rather than the new world people in Britain are more likely to borrow, but people within the Museum will not borrow—so it is a very very imperfect measure. Oddly, however, if you do that you discover that 80 per cent of the the world's ecologists are in Europe and North America and so are 80 per cent of the insect taxonomists. Only 5 per cent of the ecologists and of the insect taxonomists are in South America and Sub-saharan Africa. That is a quantification of what we said earlier. I cannot describe it; I have to hold it up. I have here a figure. The x axis is a logarithmical plotting of the number of ecologists and the y axis is taxonomists (by the above-described measure) "per country" and you will see there is a roughly linear relation. The United Kingdom, which is this point (*indicating*), sits amidst the general trend. It does not sit enormously high or low; it broadly sits in the pattern. In so far as the odd bit of testimony suggested to you that Britain is unusually high or unusually low compared to the United States, all this is relative—

1016. May I just interrupt. You are a scientist and many round this table will know that almost any function plotted on a biogarithmic scale will produce that. What can we conclude?

A. Let me get a little bit more crude. If I ask how many insect taxonomists are there in the United Kingdom versus the USA versus Australia there is an excellent study in Australia of basically every taxonomist. This includes serious amateurs. There is a study that took an enormous amount of effort but which I do not myself think was very well conducted by the Entomological Society of America in 1989 which surveyed their membership group by group. In this country we have done an informal thing on a group by group basis for the insects asking the experts how many mite people there are and so on. The numbers we arrived at on a generous estimate of serious taxonomists, curators, university people and serious amateurs was something like 150 to 200 insect taxonomists in the United Kingdom; 800 to 1,000 in the United States; and something like 141 in Australia. If you throw that against the population that is about 4 insect taxonomists per million in the United Kingdom, 4 per million in the USA and 8 per million in Australia.

1017. And per hectare?

A. Per useful hectare—I have flown over a lot of Australia which I had not seen before and a lot of it is very self-similar. I did some other numbers which I am not sure mean anything but at least they are a point of departure for discussion. What fraction of all taxonomists are in the botany category versus the animal category versus fossils. The NSF did a very big study of that. They did that by sending out a survey for which there was a 20 per cent return rate. That is a pretty flawed study. It finds that about 30 per cent of people who call themselves "systematists" are botanists, and 60 to 65 per cent work on one or other animal group, and about 5 per cent are paleontologists or paleobotanists. I do not know what that means but it is a calibration of some sort and my impression is that Britain—

1018. That would seem to be an argument for doing nothing, would it not?

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[Continued]

[Chairman *contd.*]

A. I do not think that it is an argument for doing nothing because the arguments I gave for the singularity of this subject apply equally to the United States. It is true that the funding lag is as real there. Linnaeus came as late after Newton there as anywhere else in the universe. It is based on reference collections. The fact is that the subject matter is in countries that cannot afford to study it and, yet, that is where the subject matter is. It is a bit different from nuclear physics or astronomy where the subject matter is common to everyone. The argument about the time limits, as extinctions accelerate, would be as true for the US. There is an inherent interest in whether the US does spend more on taxonomy that we do because, as many people will have said to you, the fact that the state university system in the United States is so agriculturally and practically orientated means there are very large numbers of people who do have as a fraction of their interest a taxonomic system, which for public health or agricultural reasons they are obliged to have. In taxonomy it would not surprise me if there were two or three times the number of insect taxonomists per capita in the US than in the United Kingdom but there are not or do not appear to be.

1019. It appears that tradition of the land grant colleges has been overtaken by the industrial era?

A. That would be my impression.

Lord Whaddon

1020. Professor May, can I revert back to the original question where you referred to the impression of an advanced age profile in the United Kingdom. Do you find that is a similar situation in the other countries with which you are familiar?

A. I had hoped to get a hold of such a study in the United States where I believe the same thing is true. There is, I believe, under way a study to document the age profile of taxonomists comparing it with control groups. I have been trying to get a hold of it but either it has not yet been done or I have not been able to locate the source.

1021. Do you have any impression?

A. My impression is that it is the same as here.

Chairman] I think that concludes the session. Thank you very much, Professor May, for coming.

Supplementary Notes from Professor Robert May Some Unusual Features of Research in Taxonomy and Systematics

(1) For poorly-understood reasons, the task of codifying the diversity of living things has been addressed oddly late in time. Linnaeus' pioneering classification (definitive date, 1758) comes a full century after Newton. This lag in attention and funding still has repercussions today (e.g. no central catalogue of the species that have been recorded; not even good computer catalogues for most major groups).

(2) Taxonomy and systematics is based on reference collections (which remains largely true for molecular systematics, I believe), which results in "inertial effects" hindering new players that wish to enter the game.

(3) Most catalogued diversity, and even more un-catalogued diversity, is in the tropics (largely in third world countries), yet most researchers are based in temperate zones (and the first world); see Table 1.

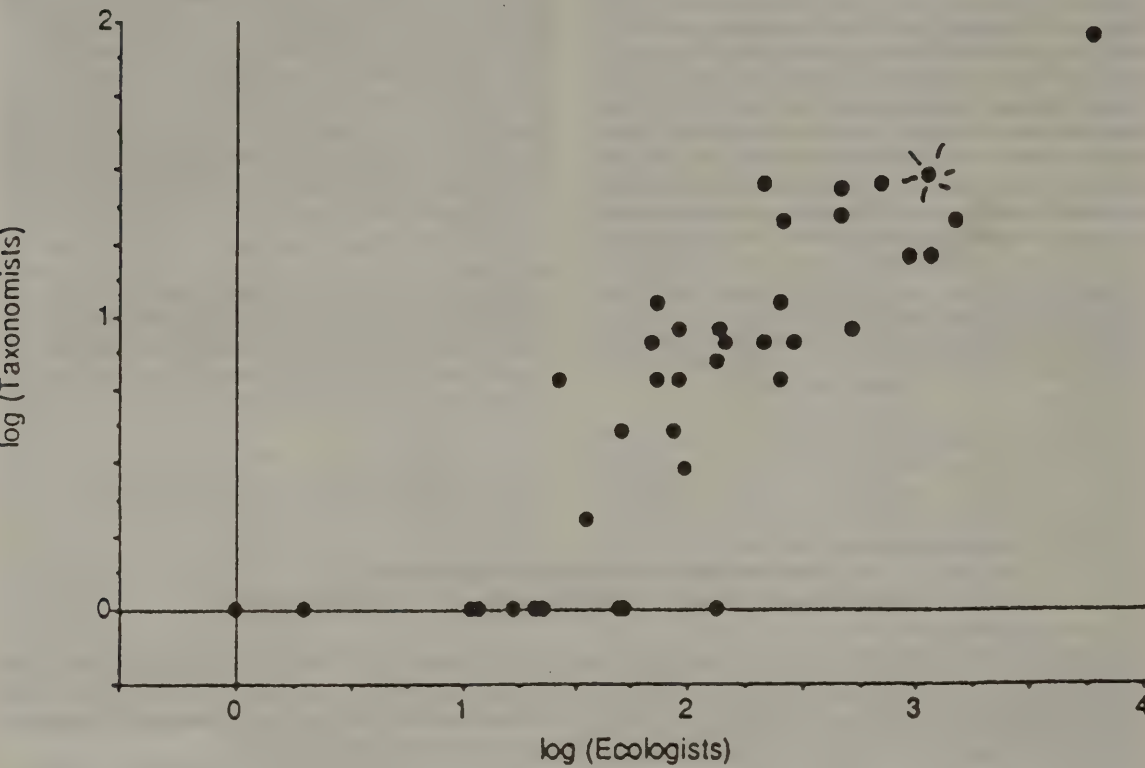
(4) Unlike essentially all other areas of science, where we can equally well address the same questions a century from now, impending extinctions make taxonomy and systematics a discipline with a time limit.

Crude measure of taxonomic "effort", by biogeographic origin of researchers.

Region	Fraction of world's ecologists, ^a per cent [N ≈ 16,000]	Fraction of world's insect taxonomists, ^b per cent [N ≈ 1,200]
Palearctic (Europe, Siberia)	35.3	53.5
Nearctic (N. America)	43.0	25.0
<i>sub-total</i>	78.3	78.5
Oriental (near east, to far east and Malaysia, etc.)	12.0	7.3 ^c
Ethiopian (sub-saharan Africa)	2.3	3.8 ^d
Neotropic (S. America)	1.7	3.5
Australasian (includes N.Z., Papua N.G., Pacific)	5.7	6.9

Notes:

- ^aCountries of origin of authors of papers listed under “ecology” in Biological Abstracts, 1984.
- ^bCrude and biased estimate, derived from analysis of countries of origin of researchers who borrowed from the BM(NH) insect collections between Jan. 1986 and June 1991. The flaws in such an estimate are obvious.
- ^cOf this 7.3 per cent, 3.6 per cent comes from Japan.
- ^dOf this 3.8 per cent, almost all — 2.9 per cent comes from S. Africa.



Each point represents a country, with “ecologists” and “[insect] taxonomists” estimated—very crudely and imperfectly—by the methods outlined in NOTES to I.

The United Kingdom is the “starred” point.

Australian fauna & taxonomists

Group	Number of Taxonomists (per cent of total)	Estimated species/taxonomists	Undescribe species/taxonomists
“Tetrapods”	190 (32per cent)	17	3
Fish	33 (6 per cent)	190	34
Insects & spiders (“entomology”)	178 (30 per cent)	~ 840	~ 400
Other invertebrates	187 (32 per cent)	~ 700	~ 430
Total	588 (100 per cent)		

*Crustacea, molluscs, echinoderms, coelenterates, sponges, helminths, [protozoa . . . not included in species/taxonomists]

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[Continued

Distribution of animal taxonomists in USA and in Australia

Group	per cent of taxonomists	
	USA ^(a) per cent	Australia ^(b) per cent
"Tetrapods"	32	32
Fish	11	6
Insects and spiders ("entomology")	32	30
Other invertebrates	25	32
Total	100	100

(a) NSF Survey, 1985. Based on 1,569 responders. These were 65 per cent of responses; 30 per cent were botanists, 5 per cent paleontologists. Rough estimates of response rate suggest total (*inclusively defined*) was 3-4 times higher = > 5,000 to 6,000 animal taxonomists [cf estimated 6,000 ecologists in USA].

(b) Total enumeration, of about 588 animal taxonomists (CS-700 ecologists in Australia).

Insect taxonomists (includes serious amateurs)

	UK order-by-order estimate: Gaston (BM (NH)) 150-200	USA order-by-order estimated: ESA, 1989 ~ 880	Australia Government Study 141
Cf. estimated number of ecologists	1,100	5,900	700
Ratio	0.16	0.15	0.20

Cautions

- (1) NSF study suggests USA insect taxonomists are ~ 20 per cent of total of 8-10,000 = > ~ 1,500 to 2,000!
- (2) UK museum "curators" total ~ 220. If 20 per cent insect = > 40-50 in museums, consistent with 150-200 total?

	UK	USA	Aust
(3) insect taxonomists			
<u>total population × 10⁻⁶</u>	= 3-4	≈ 4	≈ 8

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TAKEN BEFORE

**THE SELECT COMMITTEE ON SCIENCE
AND TECHNOLOGY**
(SUB-COMMITTEE II SYSTEMATIC BIOLOGY RESEARCH)

Tuesday 22 October 1991

MANCHESTER MUSEUM

Dr J W Franks and Dr M V Hounsome

THE NATIONAL MUSEUM AND GALLERIES ON MERSEYSIDE

Mr E F Greenwood and Dr I D Wallace

NATIONAL MUSEUM OF WALES

Mr P J Morgan and Dr B A Thomas

NATIONAL MUSEUMS OF SCOTLAND

Dr R G W Anderson and Dr M R Shaw

Mr H Barlow

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Members present:

Butterworth, L.
Cranbrook, E.
Dainton, L. (Chairman)

Nicol, B.
Porter of Luddenham, L.
Selborne, E.

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Examination of witnesses

Dr J W FRANKS, FGA, Keeper of Botany, and Dr M V HOUNSOME, Keeper of Zoology, Manchester Museum; and Mr E F GREENWOOD, Keeper of Liverpool Museum, and Dr I D WALLACE, Curator of Zoology, the National Museum and Galleries on Merseyside, called in and examined.

Chairman

1021. Thank you very much for coming, Gentlemen. I do not know whether there is anything that you would like to say by way of opening remarks, any one of you or collectively?

(*Mr Greenwood*) My Lord Chairman, perhaps I may say a little about who we are.

1022. Yes, indeed, Mr Greenwood.

(*Mr Greenwood*) I think that the National Museums and Galleries on Merseyside is an interesting museum in so far that it is the newest national museum, having been created by the Merseyside Museum and Galleries Order in 1986. Prior to that we were in the local government sector. The museum is organised into three curatorial divisions, the art galleries, the Liverpool Museum and maritime regional history. These three divisions are supported by a conservation division, which is new and developing, and a central services division. I am keeper of the Liverpool Museum and I have responsibility in addition to the museum itself for curatorial activities associated with botany, zoology, earth and physical sciences, archaeology and ethnology.

1023. May I interrupt you, Mr Greenwood, to see whether I have understood you correctly. Are you saying that since 1986 you have been funded from central government?

(*Mr Greenwood*) Yes, by the OAL,

1024. And that is when Tate in the North was set up?

(*Mr Greenwood*) Yes, I am not sure exactly of the two dates there.

1025. That is part of the whole complex?

(*Mr Greenwood*) No, the Tate is entirely separate.

1026. Yes, I see. Please continue.

(*Mr Greenwood*) My Lord Chairman, my colleague, Dr Wallace, is Keeper of Zoology.

1027. And is there anything from Manchester?

(*Dr Franks*) My Lord Chairman, yes, perhaps I may elaborate the situation in Manchester. We are now back to the same situation that we were in in the 1860s when we were founded. It began as a university museum. The city of Manchester came in with a half share round the turn of the century. At the local government reorganisation we went from the city to a half share of GMC. When GMC was abolished we

went back to being a totally university funded institution. We are subject to special factor funding at present. I am Keeper of Botany. This morning I am really here instead of Mr Warhurst, our director. Dr Hounscome is Keeper of Zoology.

1028. Thank you very much. Are there any general remarks that you wish to make about the subject under discussion, namely, systematic biology of a general kind based on your experience, that will not come out in the questioning?

(*Dr Hounscome*) My Lord Chairman, I think you have had written evidence from us. Any general remarks are probably contained in that evidence.

1029. You have all had copies of the list of questions, have you not? Would you like to work through them with us? First, in both cases you have described as the main source of your funding on the one hand the Universities Funding Council and on the other hand central government through another route. That applies both to the core curation and to the research that you are able to carry out. Can you tell us what proportion of your work is in fact involved in systematic biology?

(*Mr Greenwood*) If I may reply to that, my Lord Chairman, the question about how much of our budget is spent on biological systematic work including curation, the answer is 4 per cent. That includes the overheads borne within the central services division.

1030. And that is out of a total budget of what, Mr Greenwood?

(*Mr Greenwood*) Fourteen million, my Lord Chairman.

1031. I see, and that is all the biological systematic research you are able to do?

(*Mr Greenwood*) Yes, my Lord Chairman, and curation.

1032. That seems a very small proportion. Does it include salaries? I take it that it does?

(*Mr Greenwood*) Yes, my Lord Chairman.

1033. And for Manchester?

(*Dr Franks*) This looks in a sense like question number five to me, my Lord Chairman. We have found it very difficult to split research totally away from curation. As we have only one or at best two keeper departments it is not possible to make these divisions. We estimate that we spend 5 per cent of our

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total budget on research, and that is based on dividing the gross figure of our annual budget into thirteenthths, that is, three-thirteenthths of the gross figure.

1034. In both cases I assume that your collections are available for others for research purposes?

(*Dr Franks*) Yes, my Lord Chairman.

(*Mr Greenwood*) Yes.

1035. Have you any idea how much use is made of your collections?

(*Dr Franks*) My Lord Chairman, I can speak with precision only on figures on the botany section, which is the herbarium of the Manchester Museum. We make somewhere between 100 and 200 external loans a year, that is, world wide to all the institutions and scholars working in them.

1036. And numbers of specimens?

(*Dr Franks*) The number of specimens is never under 1,000 and it goes up to 20,000 a year.

1037. And all over the world, you say, Dr Franks?

(*Dr Franks*) Yes, my Lord Chairman, all over the world,

1038. Is this because of some special feature of your collections?

(*Dr Franks*) It is a major herbarium of international standing. It is somewhere between two and three million items. We have a lot of type specimens: we have Darwin specimens and we have Linnaean specimens. It is a very important collection, largely nineteenth century.

1039. Is that done on a cost recovery basis?

(*Dr Franks*) No, my Lord Chairman. We pay for anything that we borrow from other people; and in exchange we send out the material on our budget.

1040. Is that true for zoology at Manchester?

(*Dr Hounscome*) Yes. Because the zoology collection is not nearly so large as the botany collection the figures are a lot smaller. I should estimate it is round 100 or so a year, my Lord Chairman. However, the principles are the same. It is generally speaking the same kind of material that is called for, the types in particular.

1041. And it is done in a sense of comit of international institutions?

(*Dr Hounscome*) Yes, my Lord Chairman.

1042. Each helping the other knock for knock?

(*Dr Hounscome*) Yes, precisely.

1043. Is that the same for Liverpool, Mr Greenwood?

(*Mr Greenwood*) Yes, my Lord Chairman, we do not charge for loans. The level of loans, however, is not as great as it is in Manchester. We are talking about 100, I suppose, involving the low thousands of specimens. It is a very variable thing from year to year. In addition we have visitors to the museum, of course, perhaps one or two a day.

1044. Do you have a special relationship with the Liverpool School of Tropical Medicine or with the veterinary school?

(*Mr Greenwood*) Yes, my Lord Chairman, with the School of Tropical Medicine we do. Specifically we curate their collections, and part of the agreement for

that involves reciprocal loan, the use of teaching materials on loan and new material for research coming into the collections.

1045. So you do have a special relationship with the University of Liverpool?

(*Mr Greenwood*) Yes, we do. We have a number of agreements concerning the curation relating to collections that are in our care their use.

1046. You do not have any joint appointments?

(*Mr Greenwood*) We have no joint appointments in the natural sciences, no.

1047. But in others that are related—?

(*Mr Greenwood*) We do have a fellowship in maritime history, so it is out of this field, but it acts, if you like, as a precedent.

1048. Now given this relatively small proportion of effort that goes to research from your own funds are you able to apply for funds, for example, from research councils?

(*Mr Greenwood*) We are not. I checked on this last week with the research councils. We are not eligible to receive their grants directly. What we are eligible to do, my Lord Chairman, if we can find suitable projects with the university or, indeed, the polytechnic, is to be the industrial partner in a project, but in that case, my Lord Chairman, we should actually have to pay.

1049. But the Natural History Museum does have, since 1987, access to the research councils. Is that something that you would wish to have?

(*Mr Greenwood*) I think so, my Lord Chairman, and I say this with caution because we have a lot of informal contacts, if one can call them that, with the research councils. It is always being suggested to us that the kind of research and the kind of projects we do would not be necessarily received with favour by the research councils.

1050. Not necessarily received with favour for what reason?

(*Mr Greenwood*) Because they would not perceive the work that we do as being cutting edge science.

1051. So really, Mr Greenwood, you are an example of the general problem that we are addressing, namely, the rundown of systematic biological research, is that right?

(*Mr Greenwood*) I think so, my Lord Chairman.

1052. Is it your perception from your place in the museums, both Manchester and Liverpool, that there is a general problem here that we are trying to look at?

(*Mr Greenwood*) It would be my general perception, but I have to say, my Lord Chairman, that despite our very small budget for systematics, if you look at our figures, we have done slightly better than others, and in fact we have more people at the present time doing work curating the collections than we have had for some time.

1053. Are you a systematic biologist yourself, Mr Greenwood?

(*Mr Greenwood*) My Lord Chairman, not myself, no.

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[Continued]

[Chairman *contd.*]

1054. Perhaps then I ought to turn to the Keeper of Botany in Manchester?

(*Dr Franks*) At the moment, my Lord Chairman, I do not have a systematic project on, but I have had in the past. We can apply for SERC/NERC research grants.

1055. Because you are university owned?

(*Dr Franks*) Yes, but we do not in fact have any systematic projects being funded in that way at the moment. What we do have going on at the moment is that members of the staff are eligible for Royal Society grants for their own research. A number of members of staff have this sort of grant for the particular project or expedition.

(*Dr Hounscome*) My Lord Chairman, perhaps I may add something here. I am or I consider myself to be an active systematic biologist. As my colleague, Dr Franks, says, I am eligible for NERC and SERC grants. In fact, the teaching departments have several times asked me to take on such things, particularly to take on research students in that respect, but I have not done so for two reasons. One, as Mr Greenwood says, is that really there is very little hope of actually getting systematic biology grants from NERC or SERC. They are not seen as the "current thing", as it were. Two is that, quite frankly, because we are reduced in staff so much I do not have the time to devote that I think a research student or a research project should receive. My colleague, Dr Franks, did mention that we calculate that about 5 per cent of the budget goes on systematic research, which sounds as though it is rather more than in Liverpool, but the point about Liverpool is that it has such a wide spread of subjects that it covers whereas at Manchester we have only eight departments or so.

1056. The residue of H Graham Cannon?

(*Dr Hounscome*) Yes, my Lord Chairman, but we do teach evolution now!

1057. If I may come back to the research and curation elements that we have here in front of us, in these circumstances, with very few staff and a lot of curation work to do, how would you react to the proposition that has been put to us several times, namely, that you cannot have good relations unless there is a significant degree of research activity on the collections; or, if you do not have that research activity, that the curation really is simple preservation?

(*Dr Hounscome*) I should agree with that proposition, my Lord Chairman, yes. The relationship is symbiotic. Most of the best research, certainly that done within museums, I think is done by the people who really know their collection. The way that you really know your collection is actually to get to grips with it and do the basic curation as well. Any suggestion that you can separate curation and research is, I think, misguided.

1058. Do you feel that your curation is the poorer because only whatever it is, 4, 5 per cent, of your effort goes on research?

(*Dr Hounscome*) No, I think that that 4 or 5 per cent is enough to keep active your interest in the collection.

Lord Porter of Luddenham

1059. My Lord Chairman, may I just clarify this point about the 4 or 5 per cent of whatever. Is the remaining 94 or 95 per cent curation?

(*Dr Hounscome*) No.

1060. Presumably you have your third function of public education and the museum function. Are you able to give us some indication of how much is curation and how much is museum function?

(*Dr Franks*) My Lord Chairman, when we are talking about 5 per cent we are talking about 5 per cent of our budget, we are not talking about 5 per cent of our effort. Your research effort within a collection does not necessarily make part of the research budget.

1061. No, that I understand, Dr Franks.

(*Dr Franks*) You are being employed so the two go together. It would be, I should think, for us virtually impossible to separate out.

1062. My Lord Chairman, we are talking about curation against research. I am trying to feel for what proportion of the curation and research goes on research.

(*Dr Hounscome*) Perhaps I should point out, my Lord Chairman, that when we say 5 per cent, we are concerned here with biology. Our museum covers Egyptology, ethnology and all sorts of other departments. Therefore, that 5 per cent is not 5 per cent of the biology budget; it is 5 per cent of the museum budget. If therefore you have a lot of different departments, that figure of course gets smaller and smaller, as in the case of Liverpool.

1063. Then it is not very meaningful?

(*Dr Hounscome*) No, indeed.

1064. There would be some museums—the British Museum, I suppose—that would have zero in that category?

(*Dr Hounscome*) Yes, precisely, and conversely the Natural History Museum would have rather a lot.

1065. I wonder then whether you could give us any rough indication of what proportion of your spending is on systematic biological research and systematic biology curation? What proportion of those two goes on research, because that, I think, is what we are really looking for, my Lord Chairman?

(*Dr Hounscome*) We have in fact answered that in a written answer, my Lord Chairman. We reckon that roughly 20 per cent of our budget is spent on research currently and about 50 per cent on curation with 30 on information services. I must emphasise, my Lord Chairman, that these are guesstimates.

1066. Yes, we understand that. That you very much.

(*Dr Hounscome*) It is about 20 per cent.

Chairman

1067. But, in the case of Manchester, though not in the case of Liverpool, given the formula funding that the Universities Funding Council goes in for now, of course, you would be eligible for DR funding if you had research? Do you know what that means, the formula?

(*Dr Franks*) Not really, no.

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1068. It is simply an element that goes up with the degree of distinction of activity in research. If the department is graded on the scale one to five and it comes out five, it get a degree of support.

(*Dr Franks*) There is, I think, a further problem here, my Lord Chairman. It is that the Universities Funding Council gives a grant to the university to run the museum, but we never actually get to know what percentage, whether it is greater or smaller, of that is in fact spent on the museum, and the university will not tell us the figures that they supply to get the special factor funding. It is a very grey area, and it proves very difficult to get any figures on this area.

1069. Well, you are getting a new vice-chancellor—perhaps things will change!

(*Dr Hounscome*) Perhaps you could point out this source of funding to him, my Lord Chairman!

Earl of Cranbrook

1070. My Lord Chairman, may I just try to explore how the loans procedure is integrated with research. It seems to me that if you are sending out such a high volume of loans, up to 20 specimens perhaps, is it perhaps done on a sort of "happy families" basis, that somebody write to you saying, please send me all your hawk-weeds, or do you actually say, we should like to have our hawk-weed looked at, let us choose a hawk-weed expert. Is your loans procedure in any way tied in with your own research programme?

(*Dr Franks*) We have a guide, my Lord Chairman, and there is an index which tells all botanists all round the world roughly what we have in the way of collections. People who are doing a monograph or whatever in a particular subject, or even an ecological study, will write to us for relevant material of whatever it is they are working on. We do touch on this later, but this is one important way in which we get curation done. It is in that way that we get our material looked at by the people who are the specialists in the area in question at the time. They often will revise the nomenclature and revise the classification. Therefore, if our collection goes to somebody who is making a monograph it comes back with the latest revision, which is something, with one person on the collection, we cannot find time to do.

1071. So it is a positive part of curation policy but not a part of research policy?

(*Dr Hounscome*) Perhaps I may come back on this question also, my Lord Chairman. There are two ways in which loans are initiated. One is the passive one, which is that we are asked because somebody is doing particular revision or research. We also take a more active role in saying that we are doing some work on the curation or research of the collections and we will ask an appropriate specialist to revise our collection. We go out and say, look, would you like to see this; and that process in itself creates more interest and work for both sides, in fact.

(*Dr Hounscome*) It also does work the other way round, my Lord Chairman, in that if I, for example, am doing some research I will write to another museum and ask for a loan from their collection to me, so it is generally a two-way thing.

1072. And in turn you will curate for them?

(*Dr Hounscome*) Yes.

1073. And give them back relabelled material that you will properly identify according to your own perceptions?

(*Dr Hounscome*) Yes.

Chairman

1074. May we ask how policy is determined in these two quite different institutions in Liverpool and in Manchester?

(*Dr Franks*) As regards to loans, my Lord Chairman?

1075. Oh, no, generally. Do you have, for example, within a university a governing body for the Manchester Museum or do you have an advisory body?

(*Dr Franks*) The museum has a committee, which is about 30 strong. There are at present three biologists on the committee, two professors and an invited representative from Nature Conservancy. It so happens that at the present time all those three are botanists. Within the museum we have a senior staff meeting once a term, which is the group that does the planning within the museum itself; and we have a meeting once a week, which is a sort of work progress check meeting. That is the kind of organised committee structure.

1076. Does the main committee of 30 people advise, does it have power to direct on the programme of work that should be done in, for example, botany and zoology?

(*Dr Franks*) No, it does not. Within the university, of course, everyone is very keen on academic freedom. The direction of research policy for individuals or for the museum is not something that has ever happened. I do not know how it would be received in general. We hope and believe that the museum committee takes an intelligent interest in what the staff of the museum are doing. The committee does occasionally call members of staff in front of it to discuss matters and ask for guidance on a particular thing.

1077. But you do not have a working party on, shall we say, what should be done about the splendid botany collections given their international significance?

(*Dr Franks*) That would be a curation, not a research direction. We are of course always discussing what happens with various collections. One result of this—it is not systematics although it includes palaeontology, which as a botanist I should consider to be a systematic—is that the Earth Sciences Review awarded Manchester a special status, and the geology department now gets its funding from the Universities Funding Council directly to the museum. It is an earmarked grant that comes to the geology department and pays for two keepers and extra staff.

(*Mr Greenwood*) My Lord Chairman, may I answer the question in respect of Merseyside, which is quite different. We have a board of trustees, between 14 and 20. There are 16 at the present time. Of these 16 two are biologists. It is the policy of the board to appoint trustees who have specialisms so that within the board there is expertise across the subject areas covered by the museum. The board has

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appointed a scholarship committee. This committee meets two or three times a year and does indeed inspect the staff and their programmes. We take through the board and through the scholarship committee policies devoted to research, collection acquisition and disposal.

1078. That has given us a very good picture of your two museums, I think, and of course we recognise that in both cases very large areas of activity in your museums, greater than any you represent, also would have to be provided for. Perhaps we should go on now to some of the other questions that are more directly related to our own enquiry, systematic biology research. Do you feel over the question of documentation of collections in this country that the situation is satisfactory?

(*Dr Hounsome*) This refers to your question number 13, does it, my Lord Chairman?

1079. Yes, and take it further if you want.

(*Dr Hounsome*) When I read that question I was rather surprised because it seemed to be suggesting that we should start doing something about some kind of national scheme for collection data recording when in fact, of course, since 1980 we have had such a scheme.

1080. Is that FENSCORE?

(*Dr Hounsome*) That is FENSCORE, my Lord Chairman, yes.

1081. Tell us about that, Dr Hounsome, because we are not sure what its present status is.

(*Dr Hounsome*) Historically, if we go back, my Lord Chairman, in various regions in the country the curators in the museums decided that what was needed was a register of named collections where so-and-so's collection was. That was the basic imperative. Therefore, they formed what were called collections research units, CRUs. One of the features of the museums in the regions is that there are several museums that hold biological collections but in fact do not have biological curators. We were very concerned about this. One of the purposes was in fact to get into these institutions and record what they had. From there it grew until in the case of the north west, which was the first of these collections research units, we tried to get into every institution there was in the north west and to register which collections they had, usually by name, though sometimes there was not an associated name so we just said, a collection of birds of about one thousand or so. That is what happened. That was published. From then on the other regions did similar things. After a while it became apparent that there should be some co-ordination between the regions. The Federation for Natural Science Collections Research, or FENSCORE, as we not quite acronymically call it, was set-up and that was composed of the leading lights in the regional collections research units. It was very much a bottom up kind of thing: it came from the curators. They saw the need and they did the organisation. It was not until quite a few years later that we started to get grants from the Museums and Galleries Commission and the area services actually to organise FENSCORE. FENSCORE now is really very well established.

1082. Is it computerised?

(*Dr Hounsome*) Yes, it is, it is entirely computerised, with a copy placed at Manchester, for historical reasons, because we were the first and we have the mainframe computer, which does not cost us anything—it costs somebody something, but it does not cost us anything—and with a copy at the Museum Documentation Association in Cambridge. Four of the regions, Scotland, north of England, Yorkshire and Humberside and north west England, have published their catalogues. Two, south east and south west England, will publish by 1993. It is only Wales and Northern Ireland who have not yet participated. I should say, my Lord Chairman, that the south east includes the Natural History Museum; they have contributed to it. This forms the national database for national science collections. It is likely that FENSCORE will remain the central organising body, I should think.

1083. Is the system that you have compatible with the United States MITRE system?

(*Mr Greenwood*) My Lord Chairman, that is slightly different in that it is dealing with specimens rather than the collections. In fact, I have to say that we were slightly taken aback by this question. We find that in fact our own LASSI project is almost identical but covering all collections in museums. This is an initiative that arose initially out of the National Audit Office and Public Accounts Committee reports saying that museums should do something about the conservation and documentation of their collections. Therefore, an initiative was started through the Museums and Galleries Commission. We have a number of national museums and others participating in the project, which is a collaborative one, to look at the feasibility of common standards and so on within all museum collections. This is now up and running. The test groundwork will be starting very soon. In fact, the National Museums and Galleries on Merseyside will be the principal test site.

Earl of Selborne

1084. This question is really addressed to the representatives from Manchester, my Lord Chairman. In your written evidence you referred to the decline of the Natural History Museum research capacity and you recommended that the resources should be rechannelled to other institutions that are prepared to carry out this work. Are you suggesting that the funding—which in the case of systematic biology you recommend should come from government—should as a matter of policy be redirected back towards other areas, the Natural History Museum, Kew, Edinburgh?

(*Dr Franks*) What we perceived, I think, my Lord Chairman, was a changing philosophy in the BM, more towards being totally public display orientated. In my own specialty, in the botany collection, we have had a number of enquiries since the problems at the Natural History Museum arose of people who no longer thought that that was going to be somewhere that they were going to send their collections. They inquired of me what I thought the future of Manchester Museum was and its attitude to holding collections. There is a general discomfort therefore,

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not necessarily just with the level of funding, but with the essential philosophy of the museum.

1085. Do you think therefore that as a result of that the Government should be directing more of its research funding towards museums such as yourselves and less to the Natural History Museum?

(*Dr Franks*) I should not say less to the Natural History Museum, but I should think that there is a case for giving more to institutions like ours.

(*Dr Hounsome*) My Lord Chairman, I think that what we were saying is two things. One is that from the London end of things it is very easy to get the idea that the Natural History Museum and Kew are, perhaps not the only centres, but certainly the major centres—indeed, they are certainly the major centres. What we were pointing out in our evidence was that if we take the national collection as whole it is spread over the whole country. There is only about—I cannot remember what figures I came up with—one third in London; the rest of it is outside London. The second point therefore was that if one was considering a national plan for systematic collections this should be taken into account, namely, that funding should be spread to where the collections are, and the collections are all over the country.

Lord Porter of Luddenham

1086. My Lord Chairman, may I refer to question number four and the remarks in paragraph 7, at the fourth line, where there is a clear statement that there is a tension between the public service exhibitions and semi-popular publications and the research endeavours of the specialist staff. That is partly an answer to the question here, “Does the need to present a public image which will draw an adequate ‘audience’ put any constraints on the type of research that you can fund from this income?”. I should like to ask whether there is some feeling that research would be better done in a separate place from perhaps the university, from the museum, which has to have a public image and popularise things?

(*Mr Greenwood*) My Lord Chairman, I was wondering what the basis of that question was! In a large museum—a multidisciplinary site, with high public profile—yes, there is a tension between them in the sense that priorities have to be made between this and that part of the service. In the days of being a local authority museum there was not the slightest doubt that the public profile was the most important feature of the whole service. That remains an important part of the service. The change to a national museum puts a very high priority on carrying out scholarship, but here again it is a matter that the trustees come up against: how much should they put towards the curation, the scholarship in the institution, and how much should they put on the front door, as it were. That will always be a matter of debate and discussion, I think. The trustees are quite firm and insistent that they want to see a very strong scholastic base. To take up your Lordship’s next point about whether the research should be done in the university or in the museum, I think that that depends entirely on the nature of the research. Your Lordship earlier said, can you just curate and not do any research. I do not think that you can. You have to have a link between your curation and research.

The way that we do that is to have small units associated with collections where the more senior staff will do research, or more research, and the more junior staff will be doing the curatorial work, the basic work, so that there is a team effort here and it is seen to be a team where all the elements of it can see that they have a responsibility to the totality of it. The kind of research that we are able to do I think is sometimes described as alpha taxonomy, fairly basic and routine in a sense, but none the less, I think, very valuable. We do not have molecular biology facilities, and the university do. This is where we want to develop and are developing links between the two. Indeed, I shall be talking in the next few days about a research project with the new director of the University of Liverpool Botanical Gardens in connection with our herbarium. That is the sort of way in which I think that we can go forward.

1087. Are the research people expected to play some part in the presentation of science to the public or do they regard themselves as solely part of the museum?

(*Mr Greenwood*) No, they must take part in all activities of the museum. Presentation of science to the public is a very important part of the work.

(*Dr Wallace*) My Lord Chairman, may I say that I think the skill that we ought to have is to make our research interesting to the public. Sometimes it could influence the type of research that we should do. We might choose research that would produce either a very interesting display or something that would be of interest to the visitors at large.

Chairman

1088. Given the limitation of resources that is inevitable under any kind of government there is always going to be some kind of tension between the scholarly research and the purely curatorial end, is there not? You have in a sense already indicated that these are two different activities. Do you think that the management of the museums would be served better where there are natural history collections by having a special advisory committee with some clout or having access to research councils for monies for research so that you would be judged by your peers for quality and the necessity of the research that should be done?

(*Mr Greenwood*) My Lord Chairman, I am not sure that I can answer all those questions, but on one at least I think that we should have access to research funds and be able to compete for those like any other higher education institute. Whether there should be a grand peer review somewhere I am not so sure. I think that that might be rather difficult to impose among a wide range of organisations bearing in mind the way that they are organised and funded.

1089. There has of course been a review of taxonomy at the Natural History Museum, not once but twice, I believe. Would you welcome that?

(*Mr Greenwood*) I think that it would be quite a useful thing to have an outside peer group to look at what we are doing, but at the end of the day I think that it is a matter for the trustees.

1090. Time is running on. I wonder we might take your mind now on the essential problems that we see

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[Continued]

[Chairman *contd.*]

and know whether on the basis of your experience you agree with it. You have yourselves said in some sense that systematic biological research is not the flavour of the month. Many people have represented to us that it is nevertheless a very important subject for the purposes of conservation of global biodiversity or the fact that even the molecular genetics would not be worthwhile unless you were able to identify the plant or the animal and its relationships to others. Is it your view that systematic biological research in this country as seen from your position as curators is in a state in fact that requires some special treatment or is it just in the normal phase, subjects will go up and down, and will recover naturally?

(*Mr Greenwood*) My Lord Chairman, I think that there is a threshold level that should be maintained. The difficulty is to define what that threshold level is in quantitative terms. It would seem to me from looking outside the fence at what the universities are doing in their work in this that we may be dropping below the threshold level. If I am in the position, for example, of having to recruit staff, I think that we are definitely in the situation of having to recruit at very junior level in order to do the training upwards ourselves.

1091. You do it?

(*Mr Greenwood*) I think we have—and occasionally somebody can come in—to start at the bottom.

(*Dr Franks*) I do not know how long it will take for the natural swing to bring taxonomy up to the flavour of the month situation. However, there has been a marked change over the last two or three years with the increasing interest in the green movement and all the things that are associated with it. We are getting a lot more enquiries from a wider circle about various plants and their uses. You need to have a taxonomic training to be able to cope with this sort of enquiry. The level of that is increasing. I do not see that that ever will have an immediate effect on funding. It will take a long time to work through. We have had one or two jobs recently in the museum. If you are looking for taxonomists these days it is not too easy to find them. You think, ah, we have a job, there will be hundreds of people wanting it; but in fact that is not true, and it is not happening.

1092. Is the subject neglected in the teaching in the departments of zoology and of botany in the University of Manchester, do you think?

(*Dr Hounscome*) My Lord Chairman, I am an honorary lecturer in the department of environmental biology so I have that degree of insight. I must say though that until this year I have not been called upon to give lectures on anything related to taxonomy. I have been called upon to give lectures in ornithology in general, but this year I have actually been involved, as has another person in the museum, in a proposal to start up a course in plant taxonomy. Why they need a zoologist, I do not know.

(*Mr Greenwood*) My Lord Chairman, I should say that at the Liverpool Museum our collections are beginning to be used more now for teaching purposes within both Liverpool Polytechnic and the university. Indeed, our staff are giving the occasional lecture and seminar in the broad field of systematics.

1093. We have covered a great deal of ground. I do not know whether my colleagues have any further questions. It does occur to me that perhaps we have not elicited from you some points that you might wish to represent to us which are not covered in your written evidence or in the questionnaire which we are still examining in connection with other responses. Are there any points that you would like to make to us before we finish?

(*Mr Greenwood*) My Lord Chairman, there are perhaps two things. I think that there was one point in the questions, are there any other sources of funding, and how can we develop funding. We do a certain amount of commercial work, which is very much on the fringe of activity, if you like. The other point is that I referred to the National Audit Office and Public Accounts Committee reports. They have had very important effects for us in so far as we are now developing our conservation division—a very much bigger division than it ever was—with new buildings. Those two reports, I think, made the statements and expressed the sentiments that they expected to see the national museums put into their corporate plans how they were going to tackle the problems of conservation and documentation. We have seen on the general scope of documentation the initiative of the LASSI project and, with ourselves, the development of this conservation centre which we could put forward only on the basis of special pleading to the OAL. We are hopeful, my Lord Chairman—indeed, we have had some success already. The main problem that we have overall is the difference between the rate of inflation and the grant-in-aid that is given to us: they do not match and there is always a shortfall.

1094. Perhaps I should explain to you that I am a Commissioner of the Museums and Galleries Commission so I know about the MDA and I know about some of your activities. May I just ask, Mr Greenwood, whether you think that the Museums Documentation Association, which is in a strange relationship with the Museums and Galleries Commission at present, and we hope that it will become independent, does give a basis for providing a catalogue of material held in museums in this particular field that will be acceptable and worthwhile or is it not of sufficient fine grain?

(*Mr Greenwood*) My Lord Chairman, I am a little hesitant to say that it will. What I am equally sure is that within the framework of bodies that exist we have the basis of growth for development. The Museums and Galleries Commission, as you know, funds a bit here and a bit there, all over the place, if you like, and with the national museums they all funnel back to the OAL in the end. The basis is there; which bit is the one to develop I am not quite sure.

(*Dr Hounscome*) My Lord Chairman, are we are talking about taxonomy here perhaps I may make a point about the name of the subject with which we are working. You yourself, my Lord Chairman, mentioned biodiversity not so long ago. I think that we may be able to get a bit of a change in attitudes by changing the name of our subject. Taxonomy and systematics I think undoubtedly has the feeling of old-fashioned science. What we are increasingly discovering is that taxonomy and systematics are

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[Chairman *contd.*]

really an integral part of a much wider idea of understanding the biodiversity on the planet. If we can change the title I think we may be getting somewhere. Just as an illustration of that, my Lord Chairman, the professor of environmental biology approached me the other day on a completely separate thing asking about the possibility of setting up a special course in biodiversity, which is of course taxonomy by another name.

1095. It will not surprise you to know that in Oxford they have done a great deal of this already, as you will know, and they have produced a response from the students which is quite gratifying.

(*Dr Hounsome*) Yes.

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Examination of witnesses

Mr P J MORGAN, Keeper of the Department of Zoology, and DR B A THOMAS, Keeper of the Department of Botany, the National Museum of Wales; and DR R G W ANDERSON, FSA, FRSE Director, and DR M R SHAW, Keeper of Natural History, the National Museums of Scotland, called in and examined.

Chairman

1096. Gentlemen, thank you for coming. You have a list of questions in front of you and you know the nature of the problem. I wonder whether there are any general remarks that you would like to make that you think would be of help to us before we begin?

(*Mr Morgan*) My Lord Chairman, just for the record, the National Museum of Wales is giving evidence on behalf of three departments, geology, botany and zoology. We are a multi-site, a multidisciplinary museum, and we were created by royal charter in 1907. I have given all the details of the funding arrangements. In that one wishes to point out that they are slightly unbalanced by the inclusion of restorage costs for the collections. That has totalled roughly one million pounds over the last ten years and will continue for the next three. In questions I can break down the figures for research, curation, display, public services and restorage if required.

1097. Would you give us that information in writing, which would help us to avoid our making any errors?

(*Mr Morgan*) Yes, my Lord Chairman.

1098. You have a system of dispersal. You have a museum in north Wales. Has that added to the costs of your operation and care of your operation?

(*Mr Morgan*) Not within the actual science department, my Lord Chairman. The science departments are based in the main museum building in Cathays Park. The other major stations are the Welsh Folk Museum in St Fagans and the Welsh Industrial Maritime Museum in Cardiff docklands. The new Museum of the North is in Llanberis, and there is a series of smaller sites. The castle was a joint investigation with Clwyd County Council and with the National Portrait Gallery. Our involvement there was limited to the archaeology department and the natural science departments as such were not involved.

(*Dr Wallace*) My Lord Chairman, I believe that another major growth area is in the line of housing specimens to substantiate surveys. As environmental survey work grows in sophistication the requirement to be able to validate statements that you make about the distribution and occurrence of species will grow. Museums are the only obvious home for those specimens. It is a source of income for us. In the contracts that we do at Liverpool Museum for certain identification work we have put in that we will house the collections.

Chairman] Thank you very much for coming. We are most grateful for your evidence.

1099. So that there is really no adverse effect of that policy on the natural history collections?

(*Mr Morgan*) No, in a multidisciplinary museum our projects are put forward through the advisory committees and obviously they compete for funds with the rest of the departments, which can be a benefit as well because the total cake is larger and it gives one a better chance.

1100. Dr Thomas, is there anything more that you would like to say for Wales, or Dr Anderson for Scotland?

(*Dr Anderson*) My Lord Chairman, I should like to say that natural history collecting in Scotland originated a long time ago at the end of the seventeenth century, before the Union. We are in a sense the inheritors of those early collections. In particular we took over the collections of the University of Edinburgh in the 1850s, and it is those collections on which our current collecting is based. The natural history department and the geology department are two of six curatorial departments throughout the National Museums of Scotland. We are a multidisciplinary museum, but we do not deal with botany; the responsibility for that was devolved to the Royal Botanic Garden earlier in the century. Finally, my Lord Chairman, I should like simply to say that I am not a biologist or a geologist myself. My colleague, Mark Shaw, will be able to deal with the more detailed scientific questions that you may wish to put to us.

1101. Thank you. May I first ask what your general perception of the state of research in systematic biology is. We set ourselves up because we thought there was a problem there. The evidence that we have received has tended to confirm that.

(*Dr Thomas*) Our feeling is certainly that there has been an erosion of the base of systematic biology research in the United Kingdom much of which has been concentrated in recent years in museums.

(*Dr Shaw*) Yes, my Lord Chairman, I think that that is right. It is a question of whether the base line

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is still strong enough for more tactical research to be based upon it.

1102. Do you know the cause of this erosion? Is it something that will be naturally arrested or does it need some special measure?

(Dr Anderson) Quite a number of functions of national museums I think have been eroded in recent years simply because the increased income each year is not enough to cover the increased cost of wages and salaries within museums and something has to go. Wages and salaries typically account for between 70 per cent and 90 per cent of the total costs of the general expenses of museums. If we are only a per cent or two out on what we get each year that clearly can have a considerable effect on all our other activities.

1103. Yet people tell us that in a sense systematic biological research is coming into its own in two ways: it presents an opportunity and because of the biodiversity argument it is very necessary, and it represents an opportunity in that you cannot have all the molecular biological research done unless you can identify the animals and relate structure and form to genetic material. Is that your view?

(Dr Anderson) That might well be true, but that argument has not yet had an effect on the funding.

1104. Should it have?

(Dr Anderson) There is a number of areas in national museums where our work has been eroded and it is necessary, I think, to look not simply at one particular portion but at the whole range of functions that national museums perform. It might well be that that will be seen as the priority and therefore it should be funded better if any more money were available.

(Mr Morgan) My Lord Chairman, I think that the scale of the problem is related in zoology to the actual number of specimens that reside in the museums. There are many reports of which you will be aware such as the Museums Association's Biological Collections of the UK. That identifies the poor standard of curation. Many museums have been correcting that situation to make the collections accessible. We, for instance, have been able to draw upon a multidisciplinary conservation project and a new documentation project within the National Museum of Wales to try to catalogue some of the key material and therefore to make it available to other researchers. We have been allowed to retain income since 1984-85 and we have managed to solicit grants. To cover one point, my Lord Chairman, we are not allowed to apply to NERC or to SERC for research grants. Indeed, we cannot apply to the EC under the additionality rules so our options for research are limited. However, from the income that we have received we have put monies into temporary posts to improve curation research. What we lack is any permanent base of full-time staff who can be team leaders for researching and, if you like, investigating the collections. It is therefore the shortage of permanent staff that is the real problem.

1105. Where does this income come from?

(Mr Morgan) From the Department of the Environment, a major project on marine fish parasites into pollution, the Leverhulme Trust

looking at Quarternary mollusca and smaller grants linked to key areas of our collections.

1106. So you can receive money from another government department or from a charity but not from the research councils?

(Mr Morgan) Yes, that is correct.

(Dr Thomas) We have had money from the NRA and from CCW.

1107. What is that?

(Mr Morgan) The Countryside Council for Wales.

1108. Does it strike you as anomalous that the research councils are not approachable?

(Mr Morgan) It is, my Lord Chairman. We are currently discussing with the Welsh Office questions that we have posed, asking why this somewhat illogical position, as it seems to us, exists, and asking whether or not it is possible to allow us in line with other museums and the Natural History Museum and the universities to compete in specific fields of systematic interests where we have collections.

1109. In respect of the Natural History Museum, of course, it became possible only four years ago as a special act that it could so apply.

(Mr Morgan) Yes.

Earl of Selborne

1110. If I may follow that up, my Lord Chairman, is that the route that you would like to follow in Wales or if the case for a long-term commitment for systematic biological research was accepted would there be another route for funding that you would refer as against the research council route?

(Mr Morgan) I should be looking for some degree of increasing the permanent strength, I think. The stronger that is the greater potential we have to be successful in our grant applications because we have a firmer documentation base on the collections to use. I should not say that it was one or the other. The other way in which we can do it is to try to bring in experienced taxonomists who so to speak have retired. Taxonomists might retire but in a sense they do not "die". It is purely because they have been working on collections all their lives and have the experience that to lose them from being able to work on these collections afterwards I think is a pity. They certainly could be used very much as consultants for research contracts, and that is what we have done.

1111. As I understand it, you get annual grant-in-aid through the Welsh Office?

(Mr Morgan) Correct.

1112. From what you have said just now would it be your view that an increase in core funding, spent as you wish and employing whomever you felt most appropriate, would be the simplest solution to get the long-term funding commitment?

(Mr Morgan) Yes, but I think that it has to be earmarked. In the various reports and conferences that have been held over the last few years certain of the museums have been identified, if you like, as potential centres of excellence. One would recommend that one looks at the collection strengths and at the Natural History Museum and then at where most effectively these extra funds earmarked might go.

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[Continued]

Chairman

1113. I am interested in what you are saying here. It has been represented to us that the collections held in the United Kingdom are of special international significance and that in the context of maintaining biodiversity some special effort should be made to ensure that these are kept and balanced and complement those that are held in other countries; and that in one sense they are especially important in relation to developing countries and internationally and therefore perhaps, since we no longer have an empire and these are the products of empire, that we ought to be seeking additional international funding to support them. You made a remark about additionality which I thought was very interesting. Perhaps you would like to enlarge upon it, Mr Morgan?

(*Mr Morgan*) My Lord Chairman, the situation as it currently stands is that we were about to make an application to the EC, the fisheries agricultural research division, and this involved co-operation with Portugal, Greece, Italy, Scotland, Wales and Denmark. We had preliminary permission to proceed. We put the package together and we were told from the Welsh Office that the Treasury had looked at this and we could obviously apply but we would lose pro rata of our grant-in-aid every pound that we were successful in gaining. Seeing that the grant was over one million pounds and that we were to be the administering body with the scientific co-ordination, it means logically that two or three grants like that would reduce our grant-in-aid by 15 per cent.

1114. It hardly seems to be an incentive to get international funds, does it?

(*Mr Morgan*) They are your words, my Lord Chairman, not mine!

1115. Yes, this is, I think, a matter of concern for us. Would it also mean, for example, that if the Overseas Development Agency were to want to say, "Here's an opportunity for us to use the expertise in the collections we have here to help developing countries", the attitude of the Treasury may be to say that money coming to you from that source should not be additional to your general grant-in-aid and that there must be some corresponding reduction?

(*Mr Morgan*) I do not know, my Lord Chairman. The situation is that with each major project for outside funding we have to take it on a one by one project base to the Welsh Office. Therefore, we apply on a particular project but we do not know for certain what the answer will be. However, we do know that to the research councils we cannot apply; and, until we have a new ruling, then the EC also is not available to us.

1116. Would it be possible for someone in one of the university colleges of the University of Wales, which is reasonably close to you, to make an application to the research council to do work within your premises on your collections?

(*Mr Morgan*) With this particular grant, when we received the notification, we have very close links with the university up the road and with Professor Mike Claridge, and therefore we took the proposal to him and to the registrar; and, by the amendment of a few paragraphs, that has now gone and been submitted as a project from the University College of

Cardiff although the individual will be based in the museum working on the collections because that is where the material is.

1117. So this is a solution, but a less satisfactory one, is it?

(*Mr Morgan*) If we are to try to increase our income within the museum in order to provide more funds for more curation and more research, my Lord Chairman, yes.

1118. Some would argue that it has brought you closer to the University College and that that might be an advantage for both. Many people have said to us that the way forward in the future is for more links between the museums and the universities.

(*Mr Morgan*) Ours are fairly strong. We do run a joint insect taxonomy course with the university, which is used mainly by people from abroad. Our collections are the basis of the actual teaching.

(*Dr Thomas*) We actually teach botany courses as well at the university. A number of staff in the botany, geology and zoology departments and, indeed, in one or two other departments, are honorary lecturers in the university.

1119. I am afraid that I do not know whether there is any significant molecular biological research in your area within the universities. Have there been any attempts to bring that discipline to bear on your collections and vice versa?

(*Dr Thomas*) No, my Lord Chairman.

1120. Is it something that you would welcome if they were able to do it?

(*Dr Thomas*) Yes, my Lord Chairman.

1121. And what about Scotland?

(*Dr Shaw*) My Lord Chairman, we have been involved in molecular biology research on one or two projects involving, for example, hybridisation between wild cats and domestic cats. We have links; most of the research that we do, in fact, is collaborative in some sense with outside organisations. We do not have terribly strong links with the University at the moment I think partly because they do not have, or have not until recently had, a strong teaching of systematics; and partly because we do not have the staff time available to divert ourselves from our collections into a teaching function. It is not practicable at the moment for us to do that.

1122. It is interesting, is it not, that although they are not very strong in systematics they are very strong in molecular biology, are they not?

(*Dr Shaw*) Yes, my Lord Chairman, they are indeed.

1123. Is one the consequence of the other?

(*Dr Shaw*) That is a difficult question for me to answer! In a way the work that we should like to be basing our time on as a core function is not actually at that particular developmental front of systematics. I think that we see our role rather at the supporting end of biological sciences, at the core foundation end of providing the means for the identification of animals at a species level and providing a stable nomenclature and the means to hang information together.

1124. We ought now perhaps to pass on to the questions that have been sent to you for discussion.

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Are there any observations that you would like to make on them or shall we work through them systematically? We have, I think, covered most of the elements of funding. Your questionnaire responses revealed some of the answers. We have not touched on admission charges. I know, Dr Anderson, that you have some views on this. Would you like to tell us them?

(Dr Anderson) I am very strongly opposed to the application of admission charges because I think that it changes the nature of the institution. I have made my views known on a number of occasions about this. I am in total harmony with the views of the trustees of the British Museum that admission fees should not be applied. For a start I think that it keeps out large numbers of the public; that is quite clear. Also, as far as changing the nature of the visit is concerned, it no longer becomes possible to drop in, and I think it is the dropping in part of museum experiences which can be extremely valuable from an educational point of view.

1125. In this field, of course, it would not provide any considerable degree of funding to enable systematic biological research to be sustained?

(Dr Anderson) In Edinburgh certainly the amount of money that would be gained if it were worked out on an honest basis I think would be so little that it would make very little difference indeed. May I add something that relates to funding of curatorial research in the museum. You may have noticed that we have not made application in the same sort of way that the National Museum of Wales has done. I think that there are two reasons for this. First of all, efforts where they have been made have been to try to raise funds for exhibition work. Exhibitions are extremely expensive matters. If we are successful, as we have been, in raising 50 per cent of the cost of a new gallery the amount of money that we get with essentially the same amount of effort is very much greater. Secondly, I think that there is an element of wanting to protect the time available to curators to do research and curation within the museum. It is very easy to find oneself running around doing all sorts of things that are not directly related to the purpose for which we are employed. Dr Shaw would agree with me, I think, that we feel it very important that a reasonable proportion of the time of every curator is spent in the museum doing research. Most of our curators, in fact, I should say nearly all of them, spend a considerable amount of their own time doing research as well.

1126. Perhaps this is a good opportunity to turn to the second section of the question. How in fact do you arrange the responsibilities for research? Is it a matter of judgment for individual curators? Is it also in your view absolutely necessary to have some research for good curation?

(Dr Anderson) We do not separate curation and research, my Lord Chairman. It may partly be because of our size that it would not be a practical matter to do so. Personally I feel that research and curation are not sensibly separable in a museum. The act of curation involves looking after the collections and knowing as much as possible about them and working on them. I take perhaps a slightly old-fashioned view, but I think that you will find a

division among the national museums in the United Kingdom on this, and at least half take that view, perhaps the old-fashioned view, that curation involves both activities.

(Dr Shaw) I should agree with that, my Lord Chairman.

(Mr Morgan) We concur with that, not least because of the user element. People who receive loans and people who come to visit the museum use the collections, but it is as much the expertise of the Museum staff researcher who researches the collection himself that is important. I am certain that people who come from Britain and abroad gain just as much from talking to the curator who does research as they do in using the collection. If you have just a researcher and then a collection manager and you lose your researcher, which has happened in some museums, then the researchers from abroad will not get much change out of the collection manager.

1127. It has also been mentioned to us that in the nature of museums and their governing bodies those governing bodies cannot devote a great deal of attention to the detailed working of a particular section, especially something so complex and requiring such expert knowledge as systematic biology.

(Dr Thomas) Perhaps I may explain, my Lord Chairman, how ours operates if you would like to know that?

1128. If I may just complete the point that I was trying to make, the Museums and Galleries Commission produced a document on the national museums, in which Scotland of course was included, in which there is a chapter, Trusting the Trustees, the principle of leaving things all to the trustees. Do you think a trusteeship body is an arrangement in which it is possible for an important area like systematic biological research to be overlooked by them?

(Dr Thomas) We have a tiered system at present, my Lord Chairman. We have advisory committees to the departments. The keepers act as the chairman of those committees. The keepers' plans are therefore subject to peer review within the departmental committee. Then the keeper will take the plan, having gone through the peer review, through the system and on to the governing body of the museum, but there are no biologists on our governing body.

1129. How are these persons on your advisory committee selected? Are they experts in the particular field?

(Dr Thomas) Yes, my Lord Chairman, it was up to the keepers to suggest names to the director. Various keepers select in different ways. Generally we select six or seven people who can cover the whole field of the work of the department, including research, collections, exhibitions, and indeed who can have some overview of the external work that we do.

1130. And do they get intimate knowledge of the working of the section?

(Dr Thomas) It is a new system. They are gaining intimate knowledge.

1131. And for how long?

(Dr Thomas) It has only been going since August. My own particular committee have been once and

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they are coming again in a fortnight's time. They come and we have a set agenda, but we do have an opportunity to pick on certain items within the agenda in much more detail so they can gradually build up a good feel of what the department is all about.

1132. That seems a very sensible and practical arrangement. Does the same apply in Scotland?

(*Dr Anderson*) No, it does not. In the museum we run a rather lean system, I think, as far as committees are concerned and we try not to create them if at all possible. Each department presents its research, that is, past research and future research, programme to the trustees at successive trustee meetings one by one. Trustees also from time to time go round to the departments and see the work that is going on within the department. The scheme for research is presented as part of the corporate plan that the trustees see every year. We have one trustee who is a biologist on the board. He takes a particular interest in the work of both the natural history department and the geology department. Ultimately, however, I think that it is the responsibility of the board as a whole and, indeed, of the director to ensure that there is a proper level of research and the right kind of research operating in the museum.

1133. It just seems such a vast range of subjects to be covered that perhaps there is advantage in having some expert advice?

(*Dr Anderson*) We take expert advice in specific areas where we need it. We have indeed done that in the past, I am not sure whether in natural history, but certainly in other areas of research.

1134. There is a sense in which you have to be an expert to know that you are deficient and need expert advice?

(*Dr Anderson*) We have experts within the museum, indeed, as we have been discussing. There are not too many experts outside the museum in our particular area. I am not sure how much would be gained by discussing the particular research programmes that we are following with people who do not themselves work in that area of research.

1135. You heard the evidence that we took from Manchester and Merseyside Museums. Do you both perform services for outside customers based on your collections and do you charge for them?

(*Dr Thomas*) We do not charge, my Lord Chairman, unless we are dealing with a commercial firm.

(*Dr Shaw*) The situation is just the same with us.

(*Dr Thomas*) We identify specimens that are brought in. We certainly do not charge for that. We allow research access. We lend specimens. Indeed, we borrow specimens for our own research. We have departmental libraries that are open as well for visitors. In my own particular case at times we have large numbers of university students coming in to use our library.

1136. As part of the undergraduate course, you mean?

(*Dr Thomas*) Yes, pharmaceutical students.

1137. Perhaps we ought to turn now to the question of organisation, which is the penultimate

section. Of all subjects I suppose that systematic biological research is something of global significance for a whole variety of reasons. There are areas of specialty within this country that cover large portions of the globe. There are collections in North American institutions that cover other sections. Do you think that there is scope for any international agreements or rationalisation of collections in any way?

(*Mr Morgan*) My Lord Chairman, I believe that it would be very difficult in zoology to form an agreement like the agreement they had in botany. What happens in essence is that groups of workers, say, in mollusca are in fairly constant contact with other museums with large and small collections so there is an informal grouping that keeps contact; and you can break that down into other groups, and within sets, this occurs and on the vertebrate side as well. There are informal contacts. Maybe some of these should be put a little more into a firmer informal structure, but I doubt whether a firm agreement between museums in Britain, Europe and America is actually feasible.

(*Dr Shaw*) My Lord Chairman, I think that we all share a common attitude of co-operation rather than competition on an informal basis with the work that we try to do. There is an awful lot of collaborative research between institutions, sharing facilities and collection resources, in that way, so there is a kind of flexible, informal activity going on in any case.

1138. So you think that it is best left to its own natural development?

(*Dr Shaw*) Probably, yes. It would depend, I think, on whether earmarked funds, for example, arose. If that were to be the case there would need to be some assistance in disbursing them effectively.

(*Dr Anderson*) I think that we have got to be very careful about this question of earmarked funds, my Lord Chairman. For a start I do not think that it is feasible. There are so many areas in a museum where you could earmark funds and quite honestly I do not think that the departments who sponsor us would agree to that sort of arrangement. Secondly, however, as far as responsibilities are concerned, we are particularly exercised about having enough flexibility in the future to be able to deal with the particular financial situation in which we find ourselves. If we took on a particular responsibility it might cause all sorts of other harm to other work that we do more generally in the field. I do not think that outside co-operative organisations would be particularly happy if we felt that we had to change the nature of the agreement to suit particular financial situations.

(*Dr Shaw*) My Lord Chairman, perhaps I may just clarify what I was referring to, namely, funds within the biology research grant rather than funds within the museum provision. That is what I had in mind.

(*Mr Morgan*) In regard to the situation in respect of rationalisation of collections we put forward a view some years ago at Cardiff. I still think that there is too much concentration of seeing collections, where they are, as immutable. Now they should be able to be moved where a particular systematic researcher is based. However, in order to do that, it means that the specimens have to be transferred, as

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with loans, and need to be single item documented for them to have that kind of freedom of movement between institutions. That is very costly to try to do it in different areas, with three million specimens or six million specimens in museums. However, in certain cases where there is key research money it could in fact be done on a specific basis.

Lord Porter of Luddenham

1139. On the question of the earmarked funds, may I just ask Dr Shaw and Dr Anderson whether they agree. Dr Anderson said that it is not possible, there would be so many areas—as there would, indeed—all fighting for earmarked funds and you would have to make out a special case that systematic biology is different from all the others. Would what Dr Anderson said apply only to the museum or would he extend the argument, which Dr Shaw would not, to earmarking funds for systematic biology within the research councils?

(*Dr Anderson*) No, I was specifically talking about the funding that we get through our own sponsor department, the Scottish Office.

1140. Would not your argument apply also to earmarking outside sources because there are so many areas that would want to be earmarked?

(*Dr Anderson*) The problem about earmarking funds from our sponsoring department is that we cover such a very broad range of topics. Within the museum there would be competition for earmarked funds between, shall we say, archeology and decorative art, zoology or whatever. Where an outside funding body has specific responsibility in a particular discipline I think that it might be more possible; and I believe that that is what Dr Shaw was referring to.

(*Dr Shaw*) Yes.

(*Dr Anderson*) It is easier to determine what the priorities are in a particular discipline than across a range of disciplines.

(*Dr Shaw*) There has been a feeling, I think, that the funds that are disbursed through the research councils that have a role in biology are very concerned to support science at the cutting edge, as the phrase goes. A great deal of the work that should properly be based in taxonomic collections in museums is not science of that nature; it is at the supporting action found end of the biological science effort. It is perhaps for that reason that some different direction in the research councils, giving moneys might be sought.

Chairman

1141. That brings us to a point that I should like to raise with you from your general expert point of view. It has been represented to us not once but many times that the state of systematic biological research is not good. You possibly heard the question that was put to Manchester and Merseyside. What is your perception of it? Are you able to get people who are well qualified to join your staffs? Do you consider that the importance of the subject to which you have referred is adequately reflected in the research activities of the country in that field?

(*Dr Shaw*) My Lord Chairman, no, I believe that it is in a depressed state.

1142. Will it correct itself automatically?

(*Dr Shaw*) The end of it that is concerned with evolutionary biology and innovative research in that field to some extent I think is doing so, my Lord Chairman. However, the level of knowledge that is required in order to understand the environment and our biota on the planet I think is not going to swing back into fashion very easily. The problem is that there is going to be a short-term acute need for this information, but the provision of the information depends on a very long-term programme. It is that which is not in place at the moment.

1143. So there is a long lag phase, you are saying?

(*Dr Shaw*) It seems to me that that is the case, my Lord Chairman, yes.

1144. Are you also saying that there should be some special action now?

(*Dr Shaw*) Yes, I believe so. I think that the planet as a whole requires that from its most intelligent species.

(*Mr Morgan*) We are already 15 to 20 years behind.

1145. Behind whom?

(*Mr Morgan*) For example, behind the questions being posed by people wanting to know what the distribution of species was in Borneo in 1938 from collections throughout the museums in Britain. We cannot even answer those questions of Wales. When people are doing ecological surveys and attempt to look at local or global changes therefore we do not have the resources to be able to abstract the information from the specimens that we have.

1146. You have the material but not the people to work on them, is that it?

(*Mr Morgan*) Yes. When the researcher is doing major revisionary work on, say, marine mollusca, that was fine; but now it is the distributional data contained in the collections that are so essential and that we just do not have the manpower to extract.

1147. But if you had got the post available in this field would you be able to recruit the right people?

(*Mr Morgan*) Yes, because those particular individuals we could then train. There is no shortage of graduates that we can train. The difficulty that we have is in recruiting the top line researchers to head the teams of the people in the museums.

1148. Are you saying therefore that research in the universities in this field is curtailed?

(*Mr Morgan*) Yes.

(*Dr Thomas*) My Lord Chairman, there is also evidence that a lot of specialisms have been lost. You may lose key workers on one particular group, maybe one particular group of plants or animals: the expertise just disappears and there is nobody left.

1149. Do you think that this is a matter that should be looked at by expert groups perhaps drawn from the research councils?

(*Mr Morgan*) If I may say so, my Lord Chairman, I think that this ties in with your question number 12—and this is a personal view. Although we have FENSCORE and other groups I have always felt that there should be a body that could, if you like, both

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MR P J MORGAN, DR B A THOMAS,
DR R G W ANDERSON AND DR M R SHAW

[Continued]

[Chairman *contd.*]

keep tabs on what was happening with the expertise in collections in the United Kingdom and maybe also act as a pressure group as the ASC now does in the United States. I have believed this for many years.

1150. Are there any other points that you would like to bring to our notice? I mention this now because we have one other witness still to hear. Is there anything further that you would like to mention?

(*Mr Morgan*) My Lord Chairman, there is only one comment, from our director who is not here

today. If in fact you are coming to Cardiff to look at the university or anything else, then we should be very happy to extend an invitation for you to look at the research and curation in the National Museum of Wales.

1151. You are inviting us as human visitors, not as specimens, are you?

(*Mr Morgan*) Indeed, my Lord Chairman!
Chairman] Thank you very much.

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Examination of witness

Mr HENRY BARLOW, Naturalist, Kuala Lumpur, called in and examined.

Chairman

1152. Mr Barlow, thank you for coming from Malaysia to see us. Would you like to tell us first of all how you came to be interested in this particular field, about which you and I corresponded, and of your special relationship to the Natural History Museum as chairman of its Friends?

(*Mr Barlow*) Yes, my Lord Chairman. It has been a purely amateur relationship which has threatened to get out of control and at times become semi-professional, if not fully professional. It started from a very early age, with an interest in entomology from the age of four, which was fostered at school and has led to my being involved in entomological expeditions in south east Asia. I went out to live in south east Asia in 1970 on a permanent basis, working in an organisation looking after rubber and oil palm estates on a large scale in west Malaysia. I maintained my interest in entomology throughout that time, chiefly lepidoptera, butterflies and moths, and this has brought me into the museum on a fairly regular basis for the last 25 or 30 years. Last year in March when I went into the museum I was appalled to discover the very low level of morale among the people that I was meeting. When I looked into it it seemed to me that there was really a very serious need for some kind of support organisation out in the public at large—I was amazed to discover that there was not a Friends organisation—to create a constituency of support for what the museum is aiming to do and what it is doing, which at present it does not have. It seemed to me that if one had this sort of constituency of support it would be very much more difficult for the Government suddenly to say, “We are not going to increase your funding in line with inflation”, or, “We are going to chop your funding by 10 or 15 per cent”. That was really the beginning of my involvement in the organisation, The Friends of the Natural History Museum, which has just in the last couple of weeks been officially set up.

1153. In this context and with your longstanding contact with the Natural History Museum what is your present view of the state of systematic biological research—I do not mean just entomology alone—and I recognise that there are more species there than almost any other field?

A. I feel that it is very difficult to comment on the overall position of systematics because I am not a trained systematist and I have only come into it from the outside through entomology. It seems fairly clear to me though that the departments with which I am concerned in the Natural History Museum have been run down to a very low level. It is also a matter of considerable concern to me that staff morale, which first drew my attention to the problem in March last year, is undoubtedly still in a very serious state of disrepair. I have had evidence of that since I have been back last week.

1154. When we were in the United States taking evidence from American scientists and particularly from the US Department of Agriculture Systematic Entomology Laboratory the view expressed to us there was that the collections in the Natural History Museum were of great importance in entomology, and were in a sense things that must be kept going but that some reorganisation of the Natural History Museum was desirable and it was the manner of it rather than the nature of it that caused the dismay. Is that true in your field?

A. I think that that is probably fair comment.

1155. What is to be done generally about that particular field in entomology? Are you saying that it needs just additional resources?

A. I think it needs additional resources and the services of a really competent personnel officer within the museum as a whole.

1156. A personnel officer?

A. Yes.

1157. Oh, to look after the whole question of the morale of the staff and appointments and so forth?

A. Yes. I think it is in a disastrous state at the present time.

1158. So that is really a responsibility of the museum itself and its own organisation?

A. Yes.

1159. Given, in your language, that it has resources which keep up with inflation and the task that it has to perform, is that right?

A. Yes.

1160. Do you see from your stance any aspects of our work on which you would like to make a comment? We have been told, first, that systematic

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MR HENRY BARLOW

[Continued]

[Chairman *contd.*]

biological research is not as well developed as it should be in this country in general—and I do not just mean museums, but universities as well—and, secondly, that this is remarkable in view of the fact that the subject is intrinsically very important for theoretical biology and indeed for practical applications in biodiversity. Is that your view?

A. Yes, I think so. There is one particular view that strikes me, coming from Malaysia: that is that the costs of maintaining internationally important collections, as is done at the Natural History Museum, falls at present almost entirely on the British Government and yet the benefits as far as tropical biota are concerned of course accrue to developing countries. This I think is a major problem that requires addressing. It is difficult to see exactly how one would bring funding in from outside. But equally I think it is a fair comment that the British Government is saddled with this burden really for purely historical reasons; and it is clearly very difficult to find the funding to justify maintaining collections for the benefit of people who have now very little to do with the British Government.

1161. US AID which has given some thought to this question has recognised that there is a problem and a need takes the view that the training and the passing on of information should be done in the countries which are to benefit. That seems perhaps a little difficult if the collections are held elsewhere. What is your view on that?

A. I think it is very desirable that this should happen in the countries which are to benefit. The fact of the matter in a place like Malaysia unfortunately is that there are very few people at political level who appreciate a fraction of what is involved, what the issues are and why it is so important. I have been working on and off for the last 15 years, I suppose, to try to encourage the Malaysians to set up some form of national reference collection, so far I regret to say without any success. It is the differing perceptions, I think, in the developing countries that contribute to make this a very difficult problem.

1162. Financially, however, you could not really describe Malaysia as a developing country, could you? It has more resources per capita than many of the developing countries who could not possibly do that?

A. Yes, it certainly has the resources, if it had the political will, to turn itself into a centre for south east Asia, and it would be very nice if it were to do so.

1163. When you are thinking in your own mind of international resources for some of the developing countries what have you in mind specifically—any body?

A. I touched in my submission on the Commonwealth Agricultural Bureaux, chiefly because it is funded to a considerable extent by countries which benefit from the expertise, and also because if there was some kind of involvement in the funding from the countries which benefit I think that a lot of the problems that are currently encountered about where to lodge type specimens and, perhaps more importantly nowadays, problems of allowing foreign researchers to operate in some of these developing countries might be eased. It has become

noticeably more difficult to arrange official permission for foreign scientists, for instance, to study the natural environment in Malaysia recently. It has been very difficult for some time for foreign scientists to do this in Indonesia. I think that these problems might be addressed by some kind of contributory funding organisation which would make these countries feel that they did have a stake in their biological resources which were housed in collections overseas.

1164. Given the high profile of global environmental matters within governments do you think that there are sources of funds to be attached from there?

A. I am afraid that it is rather like getting blood out of a stone. If one approaches this problem in Malaysia it is extremely difficult to get funding for this sort of thing although, interestingly, it is remarkably easy to get funding from non-governmental organisations involved in environmental matters.

1165. Such as—?

A. Malaya Nature Society, of which I have been treasurer for the last 20 years, which is the longest standing non-governmental organisation concerned with the environment.

1166. How does it get funds of this magnitude?

A. It is involved in discussions with German and Canadian aid-giving organisations, and Americans.

1167. So you are saying you need a local organisation which has won for itself some standing, and then it can apply to individual western nations who have funds and their aid organisations?

A. Yes.

1168. It is difficult for some countries to get to that stage, is it not?

A. I suspect it is, yes.

1169. And as far as the general problem is concerned it is not a general solution?

A. I do not think so.

1170. What alternative do you propose?

A. It is really impossible to suggest any alternatives which have any hope of success except that I think there is gradually an awareness building up in places in south east Asia that the environment cannot be taken for granted. You may have seen in the papers in the last few days that the whole of peninsular Malaysia and Borneo have been covered in smog for the last two months or so. It is these sorts of development that I think are causing people to view environmental concerns in a rather different way.

Earl of Cranbrook

1171. Would you not think that there is scope for the selection on an international scale of centres of excellence?

A. There is scope certainly, but I am not sure that you can really get those off the ground unless there is somebody at a high political level in the country that you have selected to give it the necessary push.

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MR HENRY BARLOW

[Continued

Chairman

1172. You have written to us, Mr Barlow. Are there any other points that you want to bring to our attention? I did not offer you that chance at the beginning, and I must do so now.

A. Thank you very much, my Lord Chairman, but I think we have covered all the points that I had in front of me when I came in.

Lord Butterworth

1173. Perhaps I may ask just one question, my Lord Chairman. I was very interested in what you had to say about the Natural History Museum, but I was a little surprised at the last leap that you took. When you were asked about what you would recommend to change what should happen I expected you to say something about changes within the department or section concerned. I was a little surprised when your solution was a personnel officer, as it were, from the centre. I am not sure therefore that I understood how a personnel officer from the

centre could help in the problems of morale which, if I understood you correctly, sprang from dislocation within the department or within the section. It was in part academic, in other words; it was related to the nature of the work that was being undertaken. I could not quite see how a personnel officer from the centre would be able to tackle that kind of problem. Can you help on that, Mr Barlow?

A. It seemed to me that personnel changes had been so ineptly dealt with recently because of a lack of understanding of personnel management that a major problem on the morale side of the museum comes from this whole problem of personnel management.

Lord Butterworth] One wonders at the qualifications needed for a successful personnel officer of this kind—a married archangel, I suggest!

Earl of Cranbrook] With 2.1 children!

Chairman] Mr Barlow, that seems a suitable moment on which to conclude. Thank you very much for coming.

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SELECT COMMITTEE ON
SCIENCE AND TECHNOLOGY

SYSTEMATIC BIOLOGY
RESEARCH

WRITTEN EVIDENCE

WRITTEN EVIDENCE RECEIVED AFTER 21 MAY 1991

Evidence from the Association of the British Pharmaceutical Industry (ABPI)

The Association of the British Pharmaceutical Industry (ABPI) is the trade association representing the great majority of pharmaceutical companies in the UK discovering, developing and manufacturing prescription medicines. ABPI member companies supply in excess of 90 per cent of the medicines used in the National Health Service annually. In 1990 the pharmaceutical industry contributed over £1,000 million to the UK's balance of trade. This outstanding record is based on the industry's significant investment in research and development and on its close relationship with the country's centres of academic excellence. The quality of academic research in the UK is recognised internationally. We are concerned however that the current serious under-funding of science and research in the UK could be undermining the quality of the Science Base.

The ABPI is pleased to be able to contribute to the inquiry of the House of Lords' Select Committee on Science and Technology into Systematic Biology Research in the UK. The issues raised in the inquiry are wide and not all are relevant to the pharmaceutical industry. The development of systematic biology and the maintenance of reference collections is seen to be of some importance by the industry and any reduction of the present support for these areas would be viewed with much concern. The ABPI's brief comments on the ten questions raised by the inquiry follow.

(i) What is the utility of systematic biology research?

Characterisation of strains within species and comparison across species has always been central to the analysis of disease and animal models thereof. The action of new potential medicinal substances is influenced in many different ways including metabolic conversion. The availability of DNA technology to characterise at the genome level adds a new beneficial dimension to systematic biology and this advance in knowledge is in its infancy.

A number of medicines are synthesised in whole or in part by microorganisms, fungi or yeasts. Algae, plant cells and cultured mammalian cells can also be used as constituents of industrial processes. New organisms are constantly being sought by industry to produce a desired product or improve its capabilities. These organisms are sought either from natural sources or from established cultures. The new organism must be stored or preserved with minimum degradation of its genetic capabilities. Culture collections, an essential part of systematic biology research, play an increasingly important role in biotechnology. A number of leading pharmaceutical companies in the UK have active research programmes screening microorganisms and plants for natural products with novel bioactivities. Classification of any "positive" organism relies on systematic taxonomy and the provision of culture collections allows researchers to obtain related organisms. A knowledge of systematic biology facilitates description and manipulation to improve yields, and the development of new awareness of thought in this area.

Although it is not of relevance to the pharmaceutical industry it is worth noting that the development of new plant strains with increased productivity or better disease resistance draws heavily on systematic biology at the genetic level.

(ii) Does the need to specify particular organisms in connection with eg intellectual property rights, regulatory provisions etc, impinge upon your work?

The need to specify particular organisms in connection with intellectual property rights impinges significantly on the work of the pharmaceutical industry. We anticipate that there would be instances when scientists in the industry would prefer to press ahead more quickly on the use and value of an organism and leave its characterisation until later. However because of the need to obtain an early patent filing date, and the requirement to include in the patent specification an adequate description of the organism, companies do try to obtain an early characterisation.

(iii) Is the level of UK research appropriate. If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?

The ABPI has no detailed information on the level of research in systematic biology in the UK or in other countries. In view of the current funding crisis affecting the UK Science Base we anticipate that there may have been a reduction in the volume of research in this area.

We strongly believe that the provision of resources for all basis science is very important and that systematic biology should be supported qualitatively in parallel with chemistry, physiology and immunology etc.

(iv) Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate eg importance in ecological/economic terms of groups or organisms; existing spread of expertise within the country; quality of resources available?

WE have no strong opinions on this matter. However, the UK's tradition of excellence in plant science (Kew, John Innes Institute) in microbiology (Central Public Health Laboratory, Centre for Applied Microbiology and Research) and in mammalian systems would suggest a base which should be maintained and developed further.

Our comments on question 6 apply here as well.

- (v) *What is the extent of our need for reference collections including foreign material (type collections, living culture collections, etc) as a base for systematic research? Is provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?*

The pharmaceutical industry believes that it is crucial that our reference collections are maintained. They are part of the country's scientific heritage and have a key place in the world scientific community. As discussed in our comments on question (i) biotechnology makes use of bacteria, yeasts, fungi, algae, plant cells and cultured mammalian cells in industrial processes. Culture collections play a major storage role in biotechnology. They should also be active institutions of learning, research and information. Collections carry out industrially orientated research of which the pharmaceutical industry avails itself infrequently, but collections are crucial when used.

The National Culture Collections in the UK play an important role in the deposition of cultures for patent purposes under the Budapest Treaty on the International Recognition of the Deposit of Micro-organisms for the Purposes of Patents, Procedures and Regulations. The pharmaceutical industry does have some concern that only a few of the collections in the UK will accept cell lines and cell cultures as well as organisms; an expansion of the capabilities would be desirable, but not essential.

- (vi) *What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research taking cognizance of the full range of new developments in this field?*

One aspect of importance in the long term in the support of systematics is in the understanding of evolution (eg by sequence comparisons). This approach can provide much information about conservation of function.

There is considerable progress taking place in the UK in using DNA-based classification systems (including large scale sequencing) and PCR technology which will be of importance in the longer term. This, and the contingent bioinformation technology which goes with it, will need support, some of which will be enhanced by support from industry.

Using the Human Genome Project as an example, together with recent developments in biotechnology research in Europe and internationally, we would suggest that the issue of information technology needs to be examined in an international context. Competitiveness in biotechnology has to be seen as a critical determinant of commercial success, on which ultimately the country's economic strength depends. Bioinformatics is an essential part of biotechnology that underpins not only research and development but also legal, regulatory and commercial activities. Recent studies supported by the European Chemical Industry Federation (CEFIC) and the European Commission indicate academic and industrial research faces a serious threat from current United States' restrictive practices in the provision of information databases and services. There are fears that Europe lacks the infrastructure and long-term strategies to safeguard its future position. There have been calls for a bioinformatics policy for Europe with public-funding made available for a basic infrastructure so that national and international resources can be combined to maximum effect. The ABPI strongly suggests that the Sub-Committee reviews this issue as part of its present inquiry. A copy of a report by CEFIC on this matter is appended.

- (vii) *Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?*

We have little comment on these questions. There is some parallelism here with the sponsorship of protein structural data bases and DNA libraries by SERC, MRC etc. A review to address what is most effective funding process might be appropriate. We would have serious doubts however that such a review would be that effective at a time when the Research Councils are facing major deficits in their budgets.

- (viii) *If research is to be continued who pays?*

- (i) *Should burdens of expense be shared with other countries—eg an International Union of Biological Sciences (IUBS) programme? Can ESF help to rationalise activities?*

- (ii) *Within UK, how much should Government pay for and how best can budgets be protected?*

- (iii) *What role can industry play?*

We agree that in view of the international nature of research in systematic biology and the application of culture collections there should be some review into how burdens of expense could be shared with other countries.

It is worth remembering that many of the existing collections were established with the assistance of UNESCO. Culture collections in the UK are administered predominantly by public research establishments and higher education institutions. The pharmaceutical industry believes strongly that it is the responsibility of the government to maintain the infrastructure of the universities, polytechnics and research institutes. Members of The House of Lords' Sub-Committee II will be fully aware of the current crisis in the funding of the UK Science Base and how the research budgets of the Research Councils have been seriously affected.

The pharmaceutical industry has a history of successful collaboration with academia in the UK. Companies already spend substantial amounts on extramural research and much of this is in the form of capital and revenue payments to universities and other centres of academic excellence. This industry/academic liaison takes the form of contract research and collaborative research programmes. Pharmaceutical companies are keen to support the government's policy of encouraging universities etc to generate part of their income from collaboration with industry. There is however no bottomless pit of finance available for such liaison, and there are growing signs that increases in overhead charges, problems with the handling of intellectual property and an apparent decline in the quality of the UK Science Base are forcing some companies to seek collaboration in other countries.

In the context of IPR we would like to comment here on the issue of the supply of plant material for drug discovery purposes. Acquiring plants from authorised suppliers (which could include HEIs) in order to search for new medicines is a commercial undertaking in which the question of royalties is agreed before contracts are signed. How contract fees and royalties, should there be any, are spent is entirely up to the supplier to decide. A distinction must be made between collaborative and contract research with academia, including the supply of material for drug discovery purposes, and the industry's broader philanthropic support of efforts to conserve the planet's biodiversity as a whole. An example of this form of support by industry is the recent donation of £10,000 by Glaxo to the Royal Botanic Gardens, Kew, to assist its plant conservation programme.

In addition to direct grants and the sponsorship of research, industry supports academia in numerous ways in fields including systematic biology. ICI, for example, has recently donated a copy of its yeast artificial chromosome library to the MRC's Resource Centre which is playing a central role in the Human Genome Mapping Programme. The library consists of clones of human DNA propagated in yeast cells, in large units, and has already been used to identify putative human genes for cystic fibrosis.

(ix) Is HEI teaching adequate to maintain and develop the science base?

The concepts of the ABPI on the current lack of adequate funding for the UK Science Base have been raised in question 8. We are not aware of any deficiency in teaching at the undergraduate level in the field of systematic biology research. In common with all other UK research areas however, project work at postgraduate level is being severely inhibited.

The pharmaceutical industry fully endorses the conclusion of the House of Lords' Select Committee that the 1991-92 science budget is inadequate for the continuing development of the country's scientific base.

(x) What can we learn from abroad, especially the USA, Australia and Europe?

The ABPI has limited experience on this issue to be able to comment in detail. There are centralised culture collections in the United States, Japan, and Europe similar to those in the UK.

We are aware of a recent study carried out by Dr J Howells at the Centre for Urban and Regional Development Studies (University of Newcastle upon Tyne) on "Culture Collections: policy and prospects in the UK and Japan". The Sub-Committee may wish to note that paper. The European situation regarding bioinformatics has been referred to in the CEFIC report on the strategy for a European Biotechnology Information Infrastructure.

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- (i) Bio-informatics in Europe Reports 1 and 2: Strategy for a European biotechnology information infrastructure.
- (ii) Biotechnology and the Pharmaceutical Industry—Europe and Japan.
Volume No. 4: Culture Collections: Policy and Prospects in the UK and Japan.
Dr J Howells. The University of Newcastle Upon Tyne. (December 1990)

Supplementary Evidence from Professor dr P Baas, Acting Scientific Director, Rijksuniversiteit Te Leiden

Thank you for your letter of 14 June concerning the work of the House of Lords Subcommittee on Biological Systematics Research. I am very sorry that I am unable to attend the Linn. Soc. meeting about "an Appraisal of Taxonomy in the 1990s". It would be very useful for us, committee members working towards a Dutch National plan for Systematics and Evolutionary Biology, to listen to the various lectures, addressing the very themes we try to put into words in the introductory section of the plan.

The information I can give about our work towards a national plan is fairly trivial. Initiated by the Foundation for Biological Research of the Netherlands Research Organisation, a committee of project group leaders in the various subdisciplines has started to make an inventory of the various taxonomic research programmes in University Departments and other Research institutions (eg our National Natural History Museum). Representatives of all departments and organisations involved with systematics have been interviewed about their current situation and priorities for future research. The committee will propose a number of common priorities, and above all will attempt to show non-taxonomists that systematics and evolution biology are fundamental disciplines undergoing important developments as a pure science, and of vital applied importance and urgency to inventory and monitor biological diversity. Within the Foundation for Biological Research all groups of systematists have already a fairly long tradition of judging each others' annual grant proposals in a cooperative atmosphere. The number of grants for systematic PhD projects awarded per year by this underfunded agency is unfortunately very low: c. 4-5 per year. All other Ph-projects are funded from regular budgets of the departments and institutions. Altogether there are about 40 PhD students in systematics at any given time in our small country. A PhD project usually lasts four and a half years. Most graduates have a very informal, and often inefficient training programme, consisting of reading and attending very few general utility courses. To cope with this problem and with the phenomenon that our undergraduate programmes have become shorter and our graduates therefore more deficient, we are now proposing a National Graduate School for Systematics and Evolutionary Biology, with (1) courses on conceptual aspects of Systematics (phylogenetic systematics, species concepts, historical biogeography, etc); (2) methodological aspects (eg, molecular techniques such as DNA sequencing; cytological and anatomical approaches); (3) applied aspects (inventory work in order to advise on nature conservation, taxonomy of cultivated plants, etc); (4) special courses linked to groups of organisms (eg entomology, malacology, phanerogam taxonomy, mycology, algology). Most courses will only be offered once in two years, and graduates have to select a minimum number from each category of courses. Apart from making our teaching efforts more efficient, we hope this graduate school will give added value in terms of quality.

I hope this more or less answers your questions.

P Baas,
Scientific Director

Evidence from Professor R J H Beverton FRS

INTRODUCTION

1. This memo summarises my views on research in systematic biology, illustrated with reference to my special field of research in fisheries ecology and fish population biology.

2. To me, "systematic biology" is the science of the classification of living organisms on the basis of their functional and evolutionary inter-relationships. In its *general* sense, systematics provides a rational framework not only for recognising which animal (or plant) is which, but for misunderstanding the differences and similarities among them and what these mean in terms of their life-cycles, their relationships with one-another and with their environment, and how they evolved. In its *special* sense, it comprises the disciplines of taxonomy and speciation. It has strong associations with other biological disciplines, notably comparative anatomy and physiology, evolution, ecology and genetics. In fishes, systematics is fundamental to the science of ichthyology.

TEACHING

3. It is to me inconceivable to teach "whole animal" zoology or botany except in the framework of systematics as defined above, any more than it would be to teach chemistry without reference to the Periodic Table. I believe that this principle is strengthened rather than weakened by the advent of new knowledge about life at the molecular level. It applies to all teaching, from the earliest serious teaching of biology at school through to final honours degree.

4. From my admittedly limited experience of teaching from 1983-89 at Cardiff, my impression is that the use of systematics in teaching biology at school has gone out of fashion; it may have done so long ago. To give an example, the five students of my 1st year tutorial class in my last year (1989) all had B grades in A level biology but none knew what "systematics" meant or why it is important. None could tell me how a spider differed from an insect, but they could expand at length about "double-helices!"

5. I do not know the current status of systematics in the teaching of biology in the HEIS, but my impression is that, except in a few of the "old-style" biology departments, it has followed the decline in schools.

SYSTEMATICS IN APPLIED BIOLOGICAL RESEARCH (FISHERIES RESEARCH)

6. The day-to-day relevance of systematics in applied biological research varies greatly. In my own field of fisheries ecology and fish resource dynamics, many of the immediate management problems arising in the established and well-documented fisheries of, say, the North Atlantic, are as much the province these days of the mathematician and the statistician as of the biologist.

7. It is, however, becoming realised that the longer-term and more fundamental questions about the productivity of fish resources, the interactions between species and their combined response not only to fishing but to natural environmental (including climatic) changes, are requiring a return—albeit in a modern form—to the stronger biological emphasis which characterised fisheries research in the early decades of the century. The references to fisheries in the recent report of the Consultative Committee on Marine Science and Technology illustrate this point.

8. This trend gives fish systematics in its general sense a more central role, but there are some special areas of modern fisheries research where it is at the forefront. Thus, advances in *genetics* have thrown new light on the species concept as it affects the identification and assessment of fish populations and resources based on them. Some of what were thought to be separate species or self-maintaining variants of the same species are now known not to be, and *vice-versa*.

9. For example, some fascinating results have come in recent years from tracing by genetic techniques the spread and sub-speciation of the brown trout (*Salmo trutta*, L.) across Europe during the 12,000 years since the last glaciation. This research has direct relevance to contemporary problems such as the effect of acidification and hatchery releases on the survival and genetic integrity of indigenous salmonids. Again, it is now becoming realised that differences and changes in maturation, fecundity and spawning habits and migrations—all of which are basic to sound resource management—cannot be properly interpreted except in terms of what constitutes a “species” in the modern context.

10. The *conservation* of fishes and fish resources, until recently largely neglected compared with the more dramatic and “visible” conservation threats to, for example, primates and rain forests, is rapidly moving up the league table of priorities. A sound knowledge of fish systematics is fundamental to sensible conservation policy, as it is in other animal and plant groups.

11. The *introduction* of exotic fish species, either accidental or deliberate, has become widespread. The results have usually been unexpected and less advantageous than had been hoped, and sometimes with alarming consequences (as, for example, the introduction of the large predatory Nile perch *Lates niloticus* L. into L. Victoria). Attempts are being made to “rebuild” the much altered ecosystems of many of the world's largest inland waters (eg the Great Lakes of N America and the USSR), and to develop the productivity of man-made lakes (eg Kariba), in more acceptable and productive states. Again, systematic ichthyology is essential to this research and management.

12. It is perhaps in *tropical marine fisheries*, which have been growing in importance and where there is the greatest potential productivity, that the need for sound fish systematics is most urgent. As in most animals, the diversity of fish species is greatest in the tropics. Many different species—sometimes up to a hundred or so—indistinguishable except to the trained eye can be caught together and constitute an apparently unified resource. In fact, fish exhibit countless examples of convergent evolution, with superficially similar individuals actually deriving from unrelated taxa, and they may have profoundly different behaviour and responses to fishing pressure. Sound fisheries research and management in coastal tropical waters cannot be done except with a firm grounding of fish systematics.

BASIC FISH SYSTEMATICS RESEARCH

13. It will be clear from the foregoing that there is no sharp demarcation between the more fundamental and long-term aspects of fisheries research and basic ichthyology, in which is included fish systematics and taxonomy. Studies on fish have also made their special contribution to taxonomy and evolution research generally. The relative ease with which not only fish skeletons but scales and otoliths (ear-stones) are preserved in the fossil record is an added bonus. Some of the most far-reaching advances in our understanding of the processes of speciation and evolution are coming from research on fish; examples include speciation in the ancient African Rift Valley lakes and still undisturbed river systems of S America, and the light thrown on the evolution of tetrapods by the coelocanth.

Answers to questions posed in Mr Walter's letter of March 8th.

I am unable to deal with all questions equally; my best answers are as follows:

- (i) See above under Applied Research.
- (ii) Not in connection with intellectual property, but the need to identify species and refer to them correctly in publications is essential and their correct designation is insisted on by most of the top journals. Correct species identification is essential for sound fisheries management, especially in the tropics (see above).
- (iii) & (iv) Difficult to quantify in the UK context alone. The main need for new knowledge in fish systematics for applied research is in overseas applications.

- (v) Fundamental, especially as fish (unlike insects, for example) are not easily preserved. I have not myself had need for reference collections, but I have on a number of occasions sought expert advice on fish systematics. The BM(NH) is one of the world's outstanding centres of expertise and in my view this is a contribution we should continue to make to the world community.
- (vi) Basic research in fish systematics, along with that on other animal groups, is benefitting from recent advances at the molecular biology level (see above) and from statistical methods (eg cladistics).
- (vii) I consider it right for the BM(NH) to be the main centre, but good research in fish systematics can and is done elsewhere and should be encouraged, in conjunction with better teaching in the subject.
- (viii) I believe that UK policy and support for systematic biology generally, at the BM(NH) and HEIS, should be coordinated under the Research Councils so that limited skills and resources can be used to the best advantage. Prime users, (eg MAFF and DAFS in the UK and ODA for overseas fisheries R&D), should be encouraged to give guidance on practical needs. Internationally, the Fisheries Division of the FAO and the IUCN depend on an adequate basis of fish systematics in much of their work. As in other fields, many of the HEIS in developing countries endeavour to maintain a competence in basic research, despite miniscule budgets; useful fish systematic research is already being done in some of these who would benefit greatly from skilled encouragement and guidance from advanced countries, including the UK.
- (ix) No; as emphasised above.
- (x) Apart from the international pre-eminence of the BM(NH) and a few individuals at UK universities, a number of other countries, notably the USA and the USSR, are stronger in fish systematics than the UK. This can be attributed to the lack of explicit recognition of *ichthyology* as a sub-discipline of zoology in this country.

R J H Benelord

28 June 1991

Evidence from Bolton Museum and Art Gallery, Biology Curators Group

I recently received a photocopy of a letter from you originally sent to another organisation, concerning systematic biology research. This is a subject area that concerns a large number of our members and their places of work. I would like to respond to this from the Biology Curators Group, but have also passed copies to a number of key members who I am sure will also be responding. My comments are only expressed in a superficial way, due to the short time I have had available for thought and consultation with colleagues.

1. Systematic biology research underpins nearly all other biology research. Studies of ecology, pest control, habitat management, disease control and many other subject areas require a high level of taxonomic work before the organisms can be clearly identified during detailed studies. Many of the living species of the world have still not been described. There are also many instances where the lack of taxonomic research has undermined, delayed or even negated other research.

2. I do not understand what this section of your letter refers to.

3. The level of UK research is not appropriate. Much work is performed by enthusiastic amateurs and the institutions involved develop internal policies with little regard to an overall UK policy. I do not have accurate details of the volume of research, but it is a subject area that has dropped from many university courses and from research. Most museum governing bodies consider it to be of low importance and to be a waste of money. It is "out of fashion".

4. Museums are now in a much better position to be able to evaluate resources available so it should be possible to assess the position throughout the UK. However, a detailed assessment has not been performed. This assessment is vital before any action can be taken. Expertise and resources are patchy and a solid base on which to build a national policy is not available.

5. I believe that Bill Pettitt from Manchester Museum may be responding from FENSCORE and may outline some of the details concerning the uses of collections that he has been accumulating on behalf of the BCG as part of our campaign to increase the profile of biological collections and services in museums. Many problems arise in this area. Most museums still do not have the resources to conserve and curate their collections, let alone research them. Facilities for visiting researchers are often inadequate and discourage use of many collections. The Museums Association's Biology Collections UK Report illustrated these problems and showed them to be widespread.

In addition, research that generates collections as part of taxonomic work does not usually incorporate a financial element to ensure the preservation, documentation, curation and housing of a collection without the research may become worthless. This is now compounded in many university and college

museums where the collections are now seen as an expensive irrelevance. In many cases funds are being withdrawn, putting collections at risk or increasing pressure on the limited resources of other institutions who take over their care.

6. Techniques such as DNA research are gaining support. However they are outside the experience of many museum curators. Collections of value to these lines of research may therefore be overlooked. Larger museums such as the NHM have begun to address these areas of research.

7. Funding for this type of research is not secure. In addition, there must be funding so that institutions caring for taxonomically important collections are more secure. Assistance for research on these "provincial" collections based in the relevant institutions is vital.

Everyone that I consulted agreed that the DES would be a better body to have responsibility for the NHM. However, some felt that the DAL should have a role in the "public facilities" area of its work.

8.i. Yes. Expenses should certainly be shared with other countries especially within the EC. Taxonomic studies of third world organisations requires a more coordinated approach.

ii. A difficult one! The Government must recognise its responsibilities to the international community as a result of the UK's ownership of collections of fundamental importance to many other countries.

iii. It must play a greater part. Museums set up as private trusts in the USA are at the forefront of systematic research.

9. There has been a deliberate move away from teaching concerning classification and taxonomy. This has happened from primary school through to post-graduate research. The National Curriculum ● incorporate some aspects, but the emphasis overall is lower than ● years ago. Serious taxonomic training appears to be almost "extinct" in the UK.

10. See 7 part iii, above. The reaction from universities and museums abroad to the changes at the NHM say a lot! Europe as well as the US can teach us a lot.

I hope that these comments are of some value. If I, or other BCG members can be of more specific help, please contact me.

Steve Garland

Chairman

Supplementary Evidence from CAB International

Rough estimates of the current annual UK spending on Systematic Biology (including maintenance and curation of living and dead collections of importance to systematics)

	Current ¹ £ millions	Additions needed ² £ millions
The Natural History Museum	10	2
Royal Botanic Gardens Kew	9	1.5
Scottish Office (Royal Botanic Gardens Edinburgh, Royal Scottish Museum)	7	1
Welsh Office (National Museum of Wales)	2	0.5
Provincial (Local Authority) Museums	3	1
Universities (especially Oxford, Cambridge, Cardiff, Reading and Leicester)	2.5	4
Research Councils (NERC, including ITE, FBA, MBA, BAS, BRC, MRC, bacteria, viruses etc., SERC, molecular systematics, responsive research grants)	4	3
CAB International (3 Institutes)	1.5	1.5
MAFF Laboratories (collections of plant pathogenic bacteria, etc.)	0.5	—
ODA (NRI to commission studies in other institutes and universities) related to overseas biodiversity and resource surveys)	0.5	5
Board on Systematics ³	—	0.5
TOTAL	£40 m	£20 m

Notes

1. Rough approximations only based on proportions of estimated research and curation relevant to systematic biology research and services.

2. Envisaged as being dispersed from central source(s) in relation to activities controlled by the Board, *not* necessarily from the current funding departments (impractical in most cases), in order to bring the activities and standards up to appropriate levels. This money would be for ensuring the systematic research base, adequate curation of living and preserved collections, targeted research, production of identification aids and definitive floras and faunas, also development of the scientific basis of the subject, and at the university level.

3. Additional one-off costs in collection rationalization (perhaps including some new buildings) and staff relocation etc. would be necessary in years 3-5 (after 1-2 years detailed planning).

4. This would require a permanent Secretariat with an experienced systematist as Chief Executive (Research Council Secretary Grade?), support staff, funds for full Board meetings and special working groups, funding for regular consultancies into user requirements, etc.).

CAB International
Income and Expenditure Account by Service
For the year ended 31 December 1989

	<i>Total</i> £	<i>Information</i> <i>Services</i> £	<i>Scientific Services</i>				<i>Central</i> <i>Admini-</i> <i>stration</i> £
			<i>Bio-</i> <i>systematic</i> <i>Institutes</i> £	<i>CDS</i> ¹¹ <i>Lib Serve</i> £	<i>Biological</i> <i>Control</i> £	<i>Information</i> <i>Technology</i> <i>Services</i> £	
Income from operations							
Sales	6,198,413	5,889,483	168,980	57,506	21,905	57,676	2,863
Other income							
Interest	236,330	141,325	19,263	5,079	25,287	2,364	43,012
CABI tax recovery	638,475	288,172	189,962	12,393	28,236	38,724	80,988
Recoveries from third parties	140,517	32,521	95,535	4,527	434	7,500	—
Miscellaneous	140,823	50,602	32,516	—	239	—	57,466
	7,354,558	6,402,103	506,256	79,505	76,101	106,264	184,329
Expenditure							
Staff costs	7,086,299	3,110,198	1,802,595	167,676	646,029	359,558	1,000,243
Accommodation	351,078	55,388	100,396	18,588	58,101	5,725	112,880
Production	1,103,232	657,483	103,395	19,487	14,277	307,385	1,205
Communication expenses	137,271	7,482	31,775	7,236	12,831	2,467	75,480
Travel	172,261	54,597	26,983	5,698	28,507	6,179	50,297
Sales and distribution	392,303	377,668	7,670	1,971	1,470	—	3,524
Other costs	378,825	23,366	56,361	8,591	65,771	7,027	217,709
Depreciation	221,531	2,316	39,630	5,335	44,358	91,550	38,342
Increase in bad debt provision	64,000	(17,000)	—	—	81,000	—	—
Deficit on sale of assets	2,803	2,803	—	—	—	—	—
Total expenditure	9,909,603	4,274,301	2,168,805	234,582	952,344	779,891	1,499,680
Surplus on projects	894,191		296,366	23,061	574,764		
Operating Surplus/(Deficit)	(1,660,854)	2,127,802	(1,336,183)	(132,016)	(301,479)	(673,627)	(1,315,351)
Revaluation of stock and work in progress	246,000	246,000	—	—	—	—	—
Allocation of Central Administration Costs	—	(710,895)	(365,852)	(39,158)	(128,478)	(70,968)	(1,315,351)
Contributions	1,761,534	750,276	568,749	56,208	141,576	244,725	—
Net Surplus/(Deficit)	346,680	2,413,183	(1,163,286)	(114,966)	(288,381)	(499,870)	—
Proceeds of sale of Farnham House	3,626,204						
Overall Net Surplus	3,972,884						

CAB International
Income and Expenditure Account by Service
For the year ended 31 December 1990

	<i>Scientific Services</i>						<i>Central Administration</i>
	<i>Total</i>	<i>Information Services</i>	<i>Bio-systematic Institutes</i>	<i>CDS Lib Serve</i>	<i>Biological Control</i>	<i>Information Technology Services</i>	
	£	£	£	£	£	£	£
Income from operations							
Sales	6,920,866	6,597,797	161,423	51,176	2,821	106,886	763
Other income							
Interest	163,984	90,326	9,578	3,209	22,347	2,131	36,393
CABI tax recovery	731,033						731,033
Recoveries from third parties	91,800	27,847	10,000	—	3,022		50,931
Miscellaneous	288,191	82,650	133,730	3,918	1,596		66,297
Surplus on sale of assets	2,990						2,990
	8,198,864	6,798,620	314,731	58,303	29,786	109,017	888,407
Expenditure							
Staff costs	7,855,084	3,446,119	1,993,229	167,368	788,402	416,925	1,043,041
Accommodation	322,845	5,793	101,705	23,409	53,121	2,068	136,749
Production	1,311,357	811,522	95,012	27,070	6,121	348,909	22,723
Communication expenses	185,114	9,669	39,350	12,056	14,332	5,574	104,133
Travel	241,691	81,031	34,725	10,387	31,180	8,268	76,100
Sales and distribution	560,685	551,495	6,158	1,581	1,037	—	414
Other costs	402,488	19,313	59,578	8,716	68,931	5,693	240,257
Depreciation and leasehold amortisation	327,806	8,015	56,248	6,282	25,969	182,060	49,232
Bad debts written off	82,700				80,922		1,778
Decrease in bad debt provision	(81,000)				(81,000)		
Review Conference costs	91,648						91,648
Total expenditure	11,300,418	4,932,957	2,386,005	256,869	989,015	969,497	1,766,075
Surplus on projects	1,091,367		223,371	39,257	826,740	1,999	
Operating Surplus/(Deficit)	(2,010,187)	1,865,663	(1,847,903)	(159,309)	(132,489)	(858,481)	(877,668)
Allocation of Central Administration costs		(494,766)	(226,675)	(19,034)	(89,912)	(47,281)	877,668
Contributions	1,853,174	847,003	617,064	33,046	66,407	269,654	
Net Surplus/(Deficit)	(157,013)	2,217,900	(1,457,514)	(125,297)	(155,994)	(636,108)	—

Evidence from the Commission of the European Communities

Thank you very much for your letter asking for comments on systematics in the UK. Please forgive this late answer, but it remains for me a pleasure and a honour to give you a Community point of view on this matter.

Let me first make a few general remarks. We, at the Community, acknowledge the importance of systematics as the main disciplines in support of ecology research, and of the assessment and conservation of biological diversity. Its importance in the evaluation of genetic erosion is increasingly recognised. It is an ancillary discipline setting the frame for classification and ordering of research results at all levels: molecular, organism, population and ecosystem.

During the last 15-20 years, systematics has been mistreated worldwide, compared to other disciplines of biology. As a consequence, gaps in knowledge and expertise are becoming evident. However, the UK still stands out for the excellent expertise it has acquired through its long tradition in high level research in this field.

I now follow the order of the questions in your letter.

- (i) We feel that with growing service functions and budget cuts in the last 10-15 years, research itself has suffered as have many research sectors. It has probably suffered more than other sectors considered as more glamorous. Nevertheless, instead of living with competition, integration could lead to an improved situation.

- (ii) In general the answer is yes. One could possibly add improved links between molecular biology and systematics.
- (iii) The international need is obvious: the UK has unique collections, among the best in the world, e.g. for some higher plants, algae and protozoa.

Provision for storage and curation could be improved to a certain extent, but this is nothing exceptional.

As regards UK responsibilities linked to historic circumstances, one might easily argue that they do exist, as for other countries. The difference is that British reference collections are better. This offers Britain opportunities, not only for research, but also for national commercial exploitation. It also allows for a very important position within Community programmes, particularly for microbial collections. As regards publications, UK output is leading and pioneering.

- (iv) (a) improving in some areas (e.g. informatics); deserving support in others (such as linking up with molecular biology);
- (b) to our knowledge; back-sliding;
- (c) I think it deserves a higher degree of priority than it is given at present;
- (d) it is of the same level as research itself;
- (e) I have no answer.
- (v) the answer is no, and I regret it.
- (vi) we think that systematics must play a key role in any endeavour towards conservation of genetic resources and biodiversity. Therefore, we intend to support it through facilitating transnational and multidisciplinary collaborations.

F. Van Hoeck

Supplementary Evidence from the Commission of the European Communities

Thank you for your letter of 1 July 1991.

Only few resources are devoted for the moment, at Community level, to research on systematics and most of the current efforts really focus, as in the programme FOREST, upon intraspecific diversity. However, under the programme SCIENCE, certain aspects of taxonomy are considered with respect to the tropical rain forest canopy of French Guyana and in relation to two subspecies (*Mus mus domesticus* and *Mus mus musculus*) of the European mouse.

Our future programme for Biotechnology, which we hope to launch next year as a complement to the current BRIDGE programme, should contribute to the development of taxonomy information systems. We wish to place specific emphasis on the integration of molecular genetic data and biochemical information on plant taxa which lead to the improvement of plant taxonomy and the indication for industry of commercially interesting chemicals in certain plant taxa. Corresponding information network, data banks or interfaces between data banks or data sets should be created.

I am asking Dr de Nettancourt, responsible for our Biotechnology programmes, to send you a documentation on the different tools which we are generally using for facilitating transnational and multidisciplinary collaboration and to provide you, when the new Biotechnology programme is adopted, with specific information on the areas which relate to the study and protection of biodiversity.

F. Van Hoeck

Evidence from the Committee of Directors of Polytechnics

1. The Committee of Directors of Polytechnics welcomes the opportunity provided by Sub-Committee II to contribute to its debate on systematic biology research in the UK.

2. Systematic biology is the foundation upon which the framework for pure and applied research is constructed. Research into the relationships between different species can only be satisfactorily carried out if the relevant species have been properly described. The naming and cataloguing which this involved requires considerable technical competence. The rate of publication of new data indicates that the classification of species and of systematic relationships may always be incomplete.

3. The CDP recognises that the United Kingdom holds some of the most important collections of systematic material in the world. The historic circumstances of these holdings (such as the relationship with the Commonwealth) carry with them a responsibility for conserving and researching into this material, much of which has been gathered from areas of the world where diversity of species is most intense.

4. The potential of new technologies to assist the classification of systematic material is very great, but current levels of funding are insufficient to permit development of appropriate equipment, and the release of researchers from more routine tasks. Ease of access for non-specialists is an important consideration in the development of any database.

5. The decision to transfer responsibility for the National History Museum from the DES to the OAL baffled many scientists, who believe it demonstrates a lack of understanding of the role of the museum in British science.

6. Full responses are attached from eight institutions in membership of the CDP.

Supplementary Evidence from The Department of Education & Science

SYSTEMATIC BIOLOGY RESEARCH

You will recall that during the oral examination I undertook to see what further information we could offer the Committee about work in the PCFC sector (questions 190–193).

2. Our written evidence said:

“HMI report that the teaching of the traditional aspects of systematic biology (taxonomy, morphology) is satisfactory, although there is relatively little activity in this field in the PCFC sector.”

3. There is no formal written report as such. HMI have not reported specifically and separately on the teaching of systematic biology. Their advice was based on their judgement that *overall* the teaching of biology in the sector was at least satisfactory and often good. See, for example, the summaries in the three enclosed reports.

Specialist Inspectors have reported orally that on the few occasions when they have observed systematic biology being taught, they have judged the teaching to be satisfactory.

4. The oral examination also touched on the national curriculum (questions 188–189). The Committee may find the following additional information helpful?

The National Curriculum seeks to provide all pupils with a good grounding in systematic biology. Most of the material concerned is in the present attainment target number 2 (“The variety of life”). The programmes of study contain relevant material at all 4 key stages of education for pupils from 5–16. In the Secretary of State’s proposals for revised attainment targets and programmes of study, published on 20 May 1991, two of the 18 strands in the attainment targets include: “the organisation of living things” and “the diversity and classification of life-forms”. In the accompanying programmes of study, examples of the relevant requirements as to what is to be taught are:

Key Stage 2:

Children should have the opportunity to develop skills in identifying locally occurring species of plants and animals and marking these against keys, using observable structural features of organisms.

Key Stage 3:

Pupils should broaden their study of locally occurring plants and animals to other organisms and, through this, be introduced to the major taxonomic groups.

5. I attach a more complete extract of the most relevant parts of the proposed programmes of study.

Judith Partington

Secretary of State’s proposals for Science in the National Curriculum (1991)

Proposed programmes of study: Systematic Biology

Key stage 1

- Children should have opportunities, whenever possible through first hand observation, to find out about a variety of animal and plant life and become aware that some life-forms became extinct a long time ago and others have become so more recently.
- Children should sort living things into broad groups using readily observable features.

Key stage 2

- Children should investigate and measure the similarities and differences between themselves, accessible plants and animals and their fossil counterparts.
- Children should have the opportunity to develop skills in identifying locally occurring species of plants and animals and marking these against keys, using observable structural features or organisms.
- Children should develop an awareness and understanding of the necessity for sensitive collection and care of living things.

Key stage 3

- Pupils should broaden their study of locally occurring plants and animals to other organisms and, through this, be introduced to the major taxonomic groups.
- Pupils should have opportunities to group organisms on the basis of similarities and differences and to use keys to name organisms.

Key stage 4

- Pupils should use keys to assign organisms to their major groups and have opportunities to measure the differences between individuals.
 - Pupils should make a more detailed and quantitative study of a locality, including the investigation of the abundance and distribution of common species, and the ways in which they are adapted to their location.
-

Supplementary Evidence from the Department of the Environment

I promised their Lordships when giving oral evidence on 11 June, to supply certain additional information on biodiversity.

The first concerns the report of our seminar on biological diversity held at the Natural History Museum on 13 and 14 June. I understand the rapporteurs aim to complete the report by 19 July, I shall ensure that a copy of their report is sent to you as soon as it is available.

The second concerns the research project funded by DOE and DTI, on technology transfer in the conservation of biological diversity. We have together commissioned a study on the role of technology transfer in the conservation of biological diversity. Taking technology transfer in its widest sense, the aim of the study is to provide an assessment of the components which need to be addressed by UNEP and UNCED on such transfer and their role in responding to problems posed in the particular context of conserving global biological diversity.

The objectives of the study are:

- (a) To assist in establishing a working background on the role of technology transfer in conserving biological diversity, on which both developing and developed countries can agree;
- (b) To contribute to an informed debate about technology transfer in the particular context of biological diversity, and thus to help future work to move forward in a positive way.
- (c) To assist developing and developed countries to identify the scope for mutual partnership and assistance which will contribute to the international conservation efforts.

Specifically the study will review past experience, current activities and future prospects on:

- (a) The technologies, both hard (eg computers) and soft (eg training), relevant to the conservation of biological diversity, including but not exclusively those related to biotechnology.
- (b) The role of technology transfer in the conservation of the biological diversity of developing countries and, in particular, in the support of their environmental legislation and regulatory infrastructure against the background of economic pressures at work; this includes both the in situ and ex situ conservation of habitats, species and genes with the developing countries.
- (c) The institutional, Governmental, economic and infrastructure considerations which influence the ability of developing countries to absorb, maintain and fully utilise technology for achieving the aims in (b); this includes the role of intellectual and other property rights.
- (d) The likely technical advances and the time and conditions likely to be needed for their realisation.

On the basis of this assessment the study will identify what actions are currently being taken, what further measures could be pursued, and where further studies on technology transfer are required. An indication should be provided on what work would be involved to pursue any such studies.

The main study is expected to be completed in the Autumn.

D. J. Fisk

Chief Scientist

Evidence from the Forestry Commission

SUMMARY

The Forestry Commission is not greatly involved in systematic biology research. Nevertheless, there are certain key areas where there is a significant interest. These relate to studies of native tree populations on the one hand and collections of worldwide tree species and provenances on the other hand. There is also interest in systematic studies of insects and fungi.

INTRODUCTION

1. As an important part of its remit as the national Forestry Authority, the Forestry Commission is charged with the duty to undertake research relevant to the needs of forestry. This includes research into the establishment, improvement, management, protection and ecology of forest and woodland trees. The Commission has two research stations. One is at Alice Holt Lodge, near Farnham, Surrey and the other, the Northern Research Station, is at Bush Estate near Edinburgh. The Forestry Commission undertakes applied research and gives advice with the object of developing the potential of British forestry in both the public and private sectors. The Commission also undertakes research in support of policy and basic research related to the programme of applied research.

SUB-COMMITTEE INVESTIGATION

2. The Sub-Committee have invited comments on a number of specific issues. These are dealt with below in the order of the questions set out in the letter to the Forestry Commission from the Clerk of the Sub-Committee:

(i) *What is the utility of systematic biology research?*

The value of systematic biology research in forestry is threefold. First, for studies of the identity of trees or other forest organisms.

Systematic research on trees provides information at the genus, species and taxus levels. This information can be valuable for tree crops where a knowledge of specific or clonal identity may be a legal requirement for trueness to type (eg clones of poplar) or in studies of native tree populations to determine the variability of a species in its native habitat (eg species of oak). Similarly, it may be important to identify insect or fungal species or strains to determine their significance as a pest. A good example of this is the study of strains of Dutch elm disease caused by the fungus *Ophiostoma ulmi*. Strains of this fungus, more virulent than those previously found in Britain and imported in the late 1960s, were shown to be likely culprits in the present outbreak of Dutch elm disease.

Second, as an essential requirement for the selection and breeding of trees. Many of the forest trees grown in Britain have a North American origin and have a widespread geographic distribution through the United States and Canada. Some variation is found within a species (eg Sitka spruce) whereas other variability is found between closely related species or sub-species (eg in sub-species of lodgepole pine and Douglas fir). It is critically important to select the appropriate sub-species or provenance from the wide source range in North America in order to fit the particular requirements of the United Kingdom. Having selected the material best suited to the UK, a breeding programme can be initiated to cross the best parent material to provide improved progeny. A knowledge of the systematic botany of the species is essential for progress with a scientifically based improvement programme.

Third, as a basis for ecological studies. There is a range of situations, especially in ancient and semi-natural woodlands, where a detailed knowledge of a tree species and indeed other associated flora is needed in order to understand the mosaic of vegetation which has developed in relation to minor or major variations in the site.

(ii) *Does the need to specify particular organisms in connection with eg intellectual property rights, regulatory provisions etc, impinge upon your work?*

Intellectual property rights are not a particularly important issue in forestry. There are Forestry Reproductive Material Regulations where it is necessary to guarantee the pedigree of seed or clonal material. A knowledge of systematics is important here, for example acorns of different oak species are very difficult to distinguish and need expert examination.

(iii) Is the level of UK research appropriate?

Whilst there is always a demand for better systematic knowledge of our tree species for a variety of purposes including those referred to previously, we believe that the present level of research is generally appropriate to meet current basic and research applications.

(iv) Is UK research in the right areas?

Forestry research tend to concentrate on native and exotic species of potential and actual value in the UK. In forestry research there have been important shifts of emphasis in recent years to recognise the value of non market as well as market benefits of forestry. Research in this country has not stood still in this regard. For example, recent research has been carried out into the native Scots pine woodlands (the Caledonian Forest) and biochemical markers identified in order to distinguish regional origins of different Scots pine populations. This work has been invaluable in maintaining the future integrity of this important ecosystem. On the commercial side, the systematic biologies of spruce and pine have attracted particular attention for these species' obvious marketing potential.

(v) What is the extent of our need for reference collections?

The Forestry Commission manages some important collections of trees in arboreta, complementary to those of other organisations including Kew Gardens in London and the Royal Botanic Gardens in Edinburgh. The Commission's arboreta at Westonbirt (in Gloucestershire) and Bedgebury (in Kent) are particularly noteworthy.

The Forestry Commission also maintains living collection of provenances of widely grown tree species (mainly native in North America and Europe) in order to select those provenances best suited for growth in the UK (bearing in mind that the UK has only three native conifer species, Scots pine, yew and juniper). Westonbirt Arboretum, in particular, is world-renowned for its large and mature collection of trees.

(vi) What new methods are there and how will this affect future UK research?

Important progress has been made through the introduction of new methods of identification, including biochemical techniques and the sophisticated use of DNA probes. Some classical methods have become outdated, but the new methods are in general relatively much more expensive. The costs and benefits of the new techniques have to be carefully appraised. It is our view that UK research is taking full cognizance of the range of new developments in this field.

(vii) Is the current "institutionalised" base appropriate?

There is a strong case for retaining institutions expert in particular fields; this has generally been achieved for forestry.

(viii) If research is to be continued, who pays?

Systematic biology research clearly provides a sound scientific base for a wide range of potential outlets, not all of which will have an immediate or direct commercial application. This might argue that such research should be government funded. The European Community has expressed interest in maintaining a living bank of tree species and provenances, both to conserve a range of different forest ecotypes and to act as a source of plant material for selection and breeding programmes. It is not yet clear whether the EC is prepared to make a financial contribution but it could be a possible source of funds in the longer term.

The long-term nature of systematic research and the lack of clearly identifiable commercial returns generally make such research less attractive for industry support than many competing areas of research.

(ix) Is teaching adequate?

The Forestry Commission is not involved in the teaching of this subject and is therefore not well placed to comment on this particular aspect of the enquiry.

(x) What can be learnt from abroad, especially the USA?

Forestry Commission research staff maintain close links and contacts with a wide range of international forestry research institutions. The most important of these is the International Union of Forest Research Organisations (IUFRO). These contacts ensure that research staff keep abreast of the latest information and techniques.

Evidence from Avril Fox

I am very concerned about developments at the above institution over recent years, and write in the hope that the views of amateurs such as myself can be taken into consideration by your committee when discussing future developments at the Museum.

My interest is based on my experience when, from 1974 to 1981, I travelled at my own expense to a number of tropical countries where I reared lepidoptera, mostly of insects the life-histories of which had hitherto been unknown. Throughout these years I received every help from the Museum staff, and at the end I handed all my specimens and records to the Museum in the belief that the results of my work, though miniscule in comparison with the vast body of knowledge already held, would be used in perpetuity for reference.

During the course of my travels it was borne upon me with increasing force that the Museum was unique in its value to other countries, especially in the Third World, and that it was held in the deepest respect everywhere. If I had any difficulty in obtaining local information from, for example, a herbarium, I had only to ask the Museum to write in my support and the information was immediately forthcoming. Moreover the assistance given by the Museum staff in matters such as dealing with pests and diseases was of tremendous value in the countries I visited.

I rapidly realised that while the exhibition rooms of the Museum performed a useful role for casual visitors and parties of schoolchildren, the really important work went on behind the scenes, where the vast and unique collections were cared for, collated and made open to all who enquired. I know at least one first-class amateur entomologist whose interest was inspired from the day when, as a small boy, he enquired whether he might look at a collection of flies, was welcomed and was given every assistance in furthering his knowledge. I can rarely visit the Museum these days, but from what I hear, if one of my grandsons were to call there now with a similar request, as well he might, the reception would be very different. He would not obtain such easy access to the specimens his grandmother lodged, with full trust, in the care of the Museum.

There are two points to be made in this connection. One is that it can be said that the Museum represents all that was positive in the heritage left by the British Empire, which these days is so largely seen in a negative light. So many of our civil servants and army personnel, as soon as their duties were completed, rushed off with their geological hammers or collecting gear and worked lovingly into the night over the resulting specimens. Like me, they handed over what was often the work of an adult lifetime to the Museum, sure that it would be cared for and available to future enquirers. Surely our generation has a responsibility here?

The other point is that there must also be a responsibility to those countries from which these specimens were taken, and to which they are still useful for reference and information.

My anxiety is that in the present political climate, which appears to assume that research which offers no commercially rewarding perspective is therefore valueless, we are in danger of destroying a heritage which, once it is lost, can never be replaced. The main theme of what is popularly called the Pearce Report is that we should not hand on to future generations a heritage which is less than that which we ourselves received. But this is precisely what will happen if we cease the expensive curating and staffing of what we have received from the past in the Natural History Museum.

I am not qualified to suggest the solution to the dilemma in which these responsibilities place us, though I feel it a duty to draw attention to it. However, it does occur to me that if the Government feels that it is impossible to support the scientific research, staffing and public access which has until recently been the standard at the Museum, it might be best to remove altogether the scientific collections, staff and research from the Museum and the aegis of the Office of Arts and Libraries, and place them elsewhere—possibly at Kew in a separate building, and back under Science and Technology. The new unit could then be stimulated into action which could encourage funding. For example, countries which benefit from the advice of the Museum, and which can pay for this advice, should do so. Facilities could be offered for training students both from the UK and from other countries. Informative literature for use abroad could be produced. The Commonwealth, the EEC and even UNESCO could well be interested in sponsoring the unique international services which the staff can offer; there is surely money in the world in various bodies of this kind which would support such a globally valuable institution.

But at all costs, we must not destroy this unique body of living information, nor allow it slowly to die from lack of civilised appreciation.

Avril Fox

(Author of Common Malaysian Moths)

Evidence from the German Research Council (DFG)

The Sub-Committee may be interested to know that there has been concern in Germany for at least 20 years about the subject it is addressing.

Some first relatively unspecific thoughts are to be found in a memorandum "On the situation of museums" published in 1974 in which one paragraph is dedicated to the natural history museums. It should be pointed out that two museums dedicated to the natural sciences (the Senckenberg Research Institute in Frankfurt and the Zoological Research Institute and Museum Alexander Koenig in Bonn) enjoy a non-regional, national status. This is due to the fact that the former is jointly funded by the BMFT in conjunction with funding from the Länder government where it has its seat. The latter is jointly funded by the Federal Interior Ministry and the government of the Land where it has its seat.

In contrast other important state collections for systematic biology, such as there are in Stuttgart and Munich, are exclusively the responsibility of their respective Länder.

In 1982 O Kraus and K Kubitzki published a memorandum dedicated to this topic entitled "Systematic Biology". It points to the importance of taxonomy, as a fundamental basis for the biological sciences (partly in contrast to an assumed tendency that only molecular biology is worth funding)—It calls for enhanced recognition by way of university teaching appointments and consideration of the subject in university curricula.

A few years later similar statements were adopted by the European Science Foundation in Strasbourg and it may not be wrong to make enquiries there.

Recently there have been German and European attempts to adopt the expression "biodiversity"—first spread in the US by NSF and other organisations—with the express aim of emphasising the importance of taxonomy. But I am not aware of any German publication on this subject.

So much for the background to what I assume is the actual content of the enquiry.

Now for some comments on the questions in the letter:

In the past DFG (German Research Council) has not given systematic biology any special consideration in terms of its scientific subject structure or research funding. However this applies to the great majority of scientific disciplines and does not imply taxonomic research is not important to DFG. The degree of funding is small in proportion to the total funding for biology, but I am not in a position to quantify it. For once the number of biologists specialising in taxonomy is small and further more "conventional" taxonomic research is cheaper than, for instance, molecular biological research. It is not correct to say that other fields of biological research have pushed aside taxonomy even if taxonomists are somewhat inclined to present themselves as underdogs. Attempts by DFG to bring together the "classic" scientists with their "modern" colleagues (ie those working in biochemistry or molecular biology) have not been very successful, but are being continued. One example is a new DFG priority programme with the title "The molecular basis for the evolution in plants".

To my knowledge there are no regular contributions from industry towards biological taxonomic research. Which is not surprising, as regular contributions from industry for research in universities and "academic" institutions are negligible in Germany. And it is only at these institutions that taxonomic research is conducted.

Evidence from Dr. P. H. Greenwood DSc FRS

Preface: I greatly appreciate being invited by the Sub-committee to submit evidence relating to their consideration of systematic biology research in the United Kingdom.

The views expressed in this submission are derived from my experiences and thoughts as a systematist who has, for the last forty years, engaged in research on the systematics and biology of bony fishes, particularly those in the freshwaters of tropical and subtropical Africa.

In 1951 I was appointed to the staff of the East African Fisheries Research Organisation, based at Jinja, Uganda and carried out research on the fishes of Lake Victoria. In 1958 I joined the staff of the British Museum (Nat. Hist.), and remained there until my retirement in 1988, at which time I held the rank of Deputy Chief Scientific Officer (IMP). My research has embraced a number of topics within the range of systematic and taxonomic problems posed by bony fishes, and has included fairly protracted periods of field-work, including the supervision of a research team, under the aegis of the IBP, working on the productivity of Lake George (Uganda). I have also been involved in collaborative research and teaching at Harvard University, Leiden University, the Universities of Barcelona, Bergen and London, at the American Museum of Natural History, New York, and at the JLB Smith Institute of Ichthyology, South Africa.

Since my retirement I have continued research as a Visiting Fellow in the Natural History Museum, and as an Honorary Associate at the JLB Smith Institute.

(i) *The importance and utility of systematics.* Systematics, the hierarchical classification of organisms based, as far as possible, on their phylo-genetic relationships, is built on taxonomy: the recognition, description and diagnosis of organisms. The two disciplines have a reciprocally interactive relationship and both are unusual in biology because of their utilisation and integration of data drawn from all other disciplines within that science.

Systematics and especially taxonomy are fundamental to all other branches of biology since the accurate identification and naming of organisms is essential. Once one has identified and named an organism, the key is then available to all that has been written about it. Particularly in applied biology the misidentification of organisms can have disastrous, even fatal consequences. There is thus a vital need for accurate and precise taxonomy, requirements that demand frequent revisionary research as more becomes known about particular organisms and/or more comprehensive studies are made, or need to be made, of particular biotopes.

(ii) *Specification of particular organisms.* In the course of my career as a taxonomically orientated fisheries biologist, and later as a museum-based systematist and taxonomist, I was (and still am) frequently called upon to specify organisms, sometimes in an ecological context or because of regulatory provisions such as trade description and labelling acts, or to provide forensic evidence relating to presumed foreign organisms (or parts of organisms) found in processed, packaged or tinned foods. That anatomical knowledge is also used by archaeologists wishing to identify excavated objects.

(iii) and (iv) *The appropriate level of UK research, and the right areas for that activity.* This I find a difficult question to answer, in part because of its similarity to the similar problem "How long is a piece of string?"

Systematics is basically a comparative science and the objects studied pay no regard to political (and sometimes geographical) boundaries. The task of identifying and classifying living and fossil organisms is a vast one even when only the more readily accessible taxa are considered. Thus, the only answer I can provide is that the most appropriate level is the highest and most expensive one possible within the limits, of course, of available funding.

Unfortunately, systematics does not, at the moment, compare well with other biological disciplines. There are several reasons for this. One is that of changing fashions; the subject was undergoing a revival in the 50's, but has since lost out to genetics, ecology and, most recently molecular biology and genetics. Another and pragmatic reason (perhaps associated with the swing in fashions) is the availability of posts for systematics in universities, and with that the decline in the part systematics plays in the education of undergraduate students. It seems likely that this vicious circle may be broken by the links now being established between molecular biologists and the more traditional fields of systematics. The relatively few museum posts available must also have its effects.

I do not believe that one can define, at all clearly, a "right area" for research in systematics, especially one circumscribed by geographical or political boundaries. The scope of systematics is a global one, although inevitably there will be an emphasis on "local" problems, especially in countries with large and complex biotas. Ironically, many such countries are amongst the poorer in the world and thus are unable adequately to finance the necessary and extensive taxonomic research required. Ideally, that work, if undesirable lacunae in our knowledge of world biotas are not to be created, should be shouldered by other countries working in collaboration with the less affluent nations.

At least on paper it is tempting to suggest that a national policy for research should concentrate on groups of organisms having particular economic or ecological importance. However, I do not believe that this is always a realistic approach. That belief stems from the time consuming nature of fundamental systematic research, with its broad comparative basis and meticulous attention to detail; the particular ecological or economic crisis is likely to have passed before the necessary results were forthcoming. Of course there are situations where a sound, pre-existing base of taxonomic research is available and may require only rapid updating. But, on the whole, sound systematic research does not lend itself to a "commando raid" type of approach.

Furthermore, if systematics are liable to be shifted from one problem to another on the basis of presumed or forecast needs, it is unlikely that their overall contributions to the science will be as satisfactory or as fundamental as those of workers allowed to proceed along the paths of long-term specialisation usually practiced. From my experience it seems that research stemming from individual's intellectual curiosity is that most likely to produce worthwhile results.

To my mind, the best "national policy" would be one encouraging the development and expansion of systematic biology as a whole.

(v) *The need for reference collections.* Reference collections are basic to successful research, with type specimens, type series and specimens used in revisionary studies being of particular importance. As noted earlier, political boundaries do not apply to the distribution of many organisms. Since systematics

is a comparative science one cannot, therefore, draw a realistic division between native and foreign organisms. Arguments are sometimes put forward for collections to be returned to their countries of origin or to other institutions already possessing substantial collections of a like nature. To the practicing systematist that is a ridiculous concept, and one which would seriously impede the prosecution of research. It would be expensive both in terms of lost time (waiting for loans), the cost of sending out and packing loans, and the possible risk of damage to the material involved. Some of those factors are already operational, but they would be enhanced considerably if there was a widespread reshuffling of national collections.

Within the UK the storage and curation of collections housed in the major museums are adequate (but some misgivings have been expressed about those aspects in minor museums). Future budgeting must ensure that these high standards are maintained.

I am less than happy about the current Natural History Museum's policy of formally separating research and curation by dividing the career structures of staff members along those lines. It has not been shown that the previous amalgamation of research and curation was detrimental to the collections. Indeed, the opposite seems to have been true, the more so because the research *cum* curator has a personal interest in, and knowledge of, the collections stemming from his research activities. Such knowledge is unlikely to be fostered in someone only concerned with a collection's physical well-being and not with its functional (*ie* taxonomic) utility as well. Pure physical curation is a boring job and one unlikely to spark-off an interest in the other functions of a collection.

The major UK museums certainly have a scientific (and curatorial) responsibility to the world scientific community. More often than not the historical circumstances associated with the way in which those collections were amassed are closely related to, and underlie, that responsibility. For example, the collections of the NHM have a bias towards specimens collected from countries within the old Colonial empire. The majority of those now independent countries have a great need for taxonomic information relating to the plants and animals of importance in agriculture, medical biology, fisheries, and the development of conservation plans. In most instances they are also financially straitened and have not been able to train an effective number of systematists, nor to build and equip museums. They are thus largely dependent on the NHM for the solution of various taxonomic problems.

In many Third World nations there is still a great deal of basic taxonomy to be done, even with respect to organisms of economic and medical importance. Thus, the NHM's collections are of considerable importance, as also is the continuation of research by members of its staff on the material involved.

Why not, it has been suggested, return the collections to their countries of origin? Because few of these countries are equipped to curate the collections, such an action would effectively bring about the ultimate destruction of material essential to world taxonomy since many would be type specimens and others the material on which our current taxonomic knowledge of the fauna is based.

Extensive reference collections, especially ones made earlier this century (and more recently) provide the only base-lines against which present-day biotas can be compared (or, as a result of pollution and other human intrusions, can only be contrasted). In making those comparisons, useful ecological indicators are often obtained which help in the formulation of conservation policies. In those respects, collections are irreplaceable and unreproducible data-bases.

(vi) *New methods.* The use of biochemical and, especially, molecular biological techniques are currently much to the fore, and are widely available and used in the UK. Within the animal group with which I am most familiar (fishes), I consider it premature to speculate on how valid or far-reaching are the conclusions reached. One personal conclusion, however, is that wider and deeper interaction between molecular and "whole animal" systematists should be encouraged so as to enhance the understanding of each group's philosophies, techniques and limitations.

As with all new methodologies, I suspect that there may be a tendency to over-emphasise their importance and thus unduly to channel too much energy and money in their direction. That bias could be dangerous in a field like systematics where finance and workers are limited, and where "traditional" methods are likely to be widely used for a long time to come, not only as primary sources of information but also to provide the background against which the molecular systematists' results are interpreted.

(vii) *The institutionalised basis of systematic research.* I cannot see how much research, can, in the long run, be divorced from museums. Only museums can provide the essential curatorial and other support services needed (especially libraries covering a wide time-span of publications). However, that said, I do believe that more research shared between universities and museums could and should be carried out. Benefits stemming from that symbiosis would include an increase in the number of active systematists, an improved status for systematics within university courses, and an increase in the number of students ultimately attracted to systematics as a research career. Those benefits I have seen operating in university-museum cooperation outside the UK, especially in America and South Africa.

Funding. From my past experience as a senior member of the NHM's research staff I formed the clear impression that its funding base was far from secure or consistent. I also gained a distinct impression that the extent of research funding within the museum could easily be affected by the interests and

inclinations of the Director. Thus I would pose the question "Should not there be two N.H. Museums, each under separate directorship and with separate sources of funding. One museum would be devoted to systematic research (? funded from D.E.S.) and the other devoted to presenting biology *sensu lato* to the public, funded partly by self-generated monies and partly from O.A.L.). Until about a decade after the Second World War the NHM galleries in effect presented to the public the immediate outcome of research into systematic and taxonomic biology. After that time there was a distinct trend (now almost complete) towards thematic displays (evolution, human biology, ecology etc.). Admittedly those themes are all underpinned by the results of systematic biological research, but that aspect receives little or no emphasis in the displays, and galleries can no longer be considered show-cases of the Museum's "behind the scenes" activities. Furthermore the once strong links between the scientists and the display teams no longer exist. Is it not, therefore, logical and practical to give serious consideration to an administrative and financial separation of the Museums two parts?

(viii) *Who pays?* Since systematics is a global activity both in practice and through the nature of the collections held by most major museums throughout the world, there appear to be strong grounds for some international underwriting of its costs. Can, however, we seriously expect substantial contributions to come from countries (eg, apparently the UK) that already have difficulty in supporting research in their own institutes?

Other sources. Industry should support systematic biological research in those areas where, currently, it relies on expertise provided by the staff of research institutions, especially museums. Ideally, its support should go beyond simple payment and extend to the funding of industry-orientated posts in appropriate centres of taxonomic research.

Would it not be worth investigating the possibility of other areas in the public sector endowing posts for systematists in universities and museums, preferably jointly with both? The posts would be of such a nature that their holders could carry out longer-term research rather than the more *ad hoc* type usually required by industry. Appointments of the kind envisaged here would, in the long run, contribute more to the maintenance of high-quality research than the usual short-term (2-3 year) fellowship, whose period of tenure is insufficient to encourage the investigation of fundamental and often complex problems.

(ix) *Teaching.* In the UK, as opposed to my experiences in the USA, South Africa and some European countries (especially the Netherlands, Norway and Spain) the teaching of systematics is not just inadequate at the undergraduate level, it is virtually non-existent. At the postgraduate level it is generally confined to interactions between PhD students and their supervisors in museums and university departments.

For some years the NHM, in conjunction with the Zoological Society, ran a very successful and well-attended course on vertebrate diversity, for undergraduates at London University. The course included lectures and practicals on the theory and practice of systematics, and stimulated a high level of interest amongst the students. Regrettably, in part through the financial demands of the museum, and partly because the Museum's course coordinator retired, the scheme is not defunct. However, it did indicate an important role the NHM could play in higher education, and the relative ease with which such courses can be organised.

The training of systematists in the UK takes place mainly during postgraduate studies and to a considerable degree involves museum staff members. But, without stimulating interest in the discipline amongst undergraduates (and even killing potential interests through poor presentation and sometimes denigration of the subject) possible recruits are lost; the same criticisms can be levelled at the teaching of biology to 6th form pupils.

Another important phase of training can only take place once the embryo systematist is employed in a museum. In many respects, this formative period can be likened to an apprenticeship, with the newcomer learning about curation, practical techniques and procedures from an established worker. With the general cut-back in museum staffing and, in the case of the NHM, the formal separation of curation and research, the effectiveness of the apprenticeship period is endangered and is likely to be more superficial than before; a retrograde step.

(x) *Learning from abroad.* Much can be learned from the USA, particularly with regard to acknowledging the importance of systematics to biology, the integration of systematic research and teaching in universities, museums and other research institutes, and the organisation through grant giving bodies (eg the National Science Foundation) of funding for research in systematic biology.

Evidence from Sir William Halcrow & Partners Ltd

(i) Classification and subsequent identification are essential to all biological work. Without classification, all other studies from the cellular to whole-organism, laboratory or field based, become meaningless. Improvement of classification leads to the improvement of other research.

(ii) The need to specify particular organisms impinges considerably on our work. The fundamental theme of Environmental Assessment is the prediction of the effects of engineering developments on the environment and inhabiting organisms. We have staff specialised in various fields, who can normally

identify biological material to the level of class, order or beyond. However we then utilise specialised taxonomists to confirm or finalise the specific identities. In addition a major concern of EA work is the protection of rare or endangered species, which because of their rarity require identification by specialists.

(iii) We feel that systematic biology has become rather under-emphasised of late, as the orientation of research has become more and more towards areas able to demonstrate direct application. It certainly ranks below more applied disciplines, particularly those in medical fields such as genetic engineering, or those arousing particular interest such as molecular biology. However because of the fundamental nature of systematic biological research, funding must be raised to a level capable of maintaining a sufficient number of experts to cover all fields.

(iv) As Consultant Environmental Scientists, we are frequently concerned with species of economic or ecological importance. However it does not seem appropriate to concentrate effort on groups of economic importance, as these are generally reasonably well worked and funded because of their applied nature. Ecological importance could be a criterion for developing a national policy of priority groups, but this should not be at the expense of reduced funding for others. There is a definite need to provide sufficient funds for systematic research in all groups.

(v) Great Britain has historically been a world leader in systematics and taxonomy through the efforts of the early explorers and biologists. As a result many of our reference collections are unparalleled. The fact that these include considerable foreign material creates goodwill abroad and goes some way to maintaining our reputation for scientific excellence at a time when scientific and other funding has been reduced, and our word standing in other fields has fallen. We do have a responsibility to the world scientific community to maintain and add to these collections. The traditional leadership of the British Museum should be maintained together with other centres of excellence such as the Royal Botanical Gardens, Kew.

(vi) Computerised methodologies have important applications in systematics research, and the usage of databases and dendrogram software is now widespread. However computerised techniques change so rapidly that it is easy for institutions to be left behind in the usage of new software. The answer would be to provide funds to enable the employment within the major systematic institutions of software development and utilisation expertise.

(vii) Academic institutions are the appropriate place for systematics research. Although the environmental industry has the need for such services, generally they do not have the required facilities or expertise. The funding base should be secured because of the fundamental importance of such research.

(viii) Industry in general would probably be reluctant to provide major funding for systematics research, except for altruistic reasons, because of its lack of direct application. It would be more appropriate for the majority of the funds to come from government, supplemented by EC funding, together with bequests and industrial funding if available.

(ix) In universities the teaching of systematics tends to suffer because of the tendency to promote the currently popular fields such as molecular biology. Perceived traditionally as a "dry area" the teaching of systematics tends to be similarly lacking in stimulation. The increased usage of computer technology, and innovative practical classes and lecturing techniques should be encouraged.

Letter to the Chairman from the International Society of Hymenopterists

Dear Lord Dainton

The International Society of Hymenopterists held their 2nd Quadrennial meeting 11–17 August in Sheffield during which many aspects of the study of bees, wasps, ants and parasitic wasps were discussed. A major topic of discussion during the week was the importance of Hymenoptera to biodiversity studies and the lack of funding to pursue vital and necessary systematic studies of this important group of insects. As a result of these discussions, the enclosed resolution was passed and is hereby forwarded to you for presentation to your committee.

Thank you for your consideration of this issue.

Sincerely,

Paul M. Marsh, President
International Society of Hymenopterists

Resolution

Whereas the World is currently in a biodiversity crisis;

Whereas insects form the largest single portion of the World's biological diversity;

Whereas hymenopterous insects (ants, bees, wasps, parasitic wasps) are a major and important component of insect diversity in terms of both species numbers and biomass, and yet their systematics and biology remain largely unknown;

Whereas Hymenoptera are directly beneficial in economic terms due to their role in pollination and biological control, and directly beneficial in ecological terms through a reduced reliance on pesticide usage due to their importance to biological control;

Whereas Hymenoptera play a vital role in preserving ecological balance and stability in terrestrial ecosystems;

Whereas Hymenoptera promote the maintenance of high diversity in other organisms through their role as pollinators, and their ability to influence community structure and regulate population size in other arthropods;

Whereas Hymenoptera are an extinction-prone group;

Whereas we are currently entering into a period of mass extinctions, where extinction rates may be several thousand times higher than normal;

Whereas the differential loss of Hymenoptera species through extinction will result in drastic further effects on the environment in terms of ecosystem perturbations and extinctions of other plant and animal species, resulting in the loss of poorly known species before we have a chance to assess them for any potential beneficial value;

Be it resolved that The International Society of Hymenopterists urges that the study of systematics, biology, and ecology of Hymenoptera must be made an integral part of future research strategies aimed at cataloguing and surveying the World's biological diversity, and in particular, that funding for the study of Hymenoptera systematics be placed much higher on the funding agenda than has hitherto been the case.

Resolution passed 15 August 1991 at the 2nd Quadrennial Meeting of The International Society of Hymenopterists, Sheffield, UK, 11–17 August 1991.

Evidence from the International Union of Biological Sciences

The following submission is made on behalf of the International Union of Biological Sciences by Professor W D L Ride, AM FTS MA DPhil, Vice President of the Union and Chairman of the IUBS Standing Committee on Taxonomy and Nomenclature.

Introduction to Submission: The International Union of Biological Sciences (IUBS) is one of the Unions of the International Council of Scientific Unions (ICSU). It consists of Ordinary and Scientific Members. The former consist of national academies or other appropriate national institutions. The latter consist of international professional bodies. Great Britain adheres to the Union through the Royal Society.

As a matter of policy, the Union does not seek to intervene in the internal policies of nations represented within it. However, the Union makes resolutions from time to time at its General Assemblies. These, expressing, as they do, the international and corporate scientific opinion of its members, may be promoted by the organizations of member countries to influence national policies.

Therefore, while it would not be appropriate for the Union to comment on the state of systematic biology research in the UK, it is appropriate for the Union to convey to you its concerns on the need for support for systematic biology generally, and its most recent resolutions, in the hope your Committee will find it possible to take steps in the UK to promote biosystematic science in a manner sought in the resolutions.

Resolutions made by General Assemblies of IUBS: Copies of portions of Proceedings of IUBS General Assemblies containing Resolutions on Systematic Biology are appended to this submission (attachment A) (not printed). In summary they:

- express the view that proper development of knowledge of the kinds and distribution of organisms throughout the world is basic to the development of biological science;
- recognize that systematic research provides a fundamental framework for all biological research and education, and for communicating information on organisms in agriculture, commerce, medicine, and other activity relating to biological products;
- stress the urgency to promote systematic studies in view of world-wide ecosystem modification and destruction;
- express concern that there appears to have been a progressive loss of trained taxonomists in recent decades and a current dearth of taxonomic expertise;
- stress the urgent need for increased taxonomic education
- observe that taxonomic collections are inadequate and poorly supported in many countries—and especially in developing countries;

- urge international and national bodies to support development of taxonomy and biological collections;
- urge international and national bodies to support the international bodies responsible for the International Codes of Nomenclature to promote the use of stable and universally accepted scientific names and animals; and
- request the international scientific bodies responsible for the International Codes of Nomenclature to achieve greater harmony between the different Codes, and to review their operation in the light of new developments in science and information technology.

Arrangement. The headings used in the submission follow the issues raised in your letter to IUBS of 18 March. Other points raised in your supplementary letter of 17 April are dealt with, where appropriate, within the same framework.

- (i) *Utility:* Research in systematic biology results in knowledge of relationships and the distribution of organisms in time and space. Its utility lies in its by products. These are:
 - tools whereby organisms can be identified as biologically meaningful units.
 - names for organisms that are unambiguous, stable, and used universally
 - that, since related organisms share inherited characteristics, the properties and responses of little known organisms can be inferred from their systematic positions—this aspect provides the first approach to many control and management programs.
 - that these outcomes, taken together, provide the information infrastructure upon which all biological sciences depend.
- (ii) *Regulatory provisions:* The International Unions of ICSU have steadfastly maintained a view that national bodies should not adopt internal measures that would impede the free movement of scientists or scientific research. The Union would urge your Committee to consult widely (and internationally) on this matter before recommending measures that might have the effect of impeding the development of biological science, or to further restrict the benefits of science to developed countries, and at the expense of developing countries.

Although it is undesirable for nations to adopt measures that would unilaterally restrict free movement of biological material for scientific research, your Committee's attention is drawn to the existence of international agreements and protocols made within UNESCO and IUCN for the purpose of protecting world heritage and endangered and threatened species. Such instruments express international agreement that in certain cases it is desirable to place restrictions upon transfer of ownership and the movement of taxonomic collections, and upon collecting activities by research institutions such as museums and herbaria.

- (iii) *Level of systematic research:* While it would not be appropriate to comment on the level of research in the United Kingdom, IUBS can fairly comment on levels generally and on competition between systematics and other biological disciplines.

From the summary of IUBS resolutions, it can be seen that the Union is concerned that diminished effort is posing a major taxonomic impediment to biological research and applied biology. Since the utility of systematic research lies in its production of infrastructure, the utility of any particular piece of taxonomic research may not be apparent until long after it is completed. Hence in any funding system that reflects political and immediately utilitarian priorities, taxonomic research is liable to fare badly by comparison with other more immediately applicable work requiring funds. Accordingly, the Union would hope that your Committee will give consideration to measures designed to ensure the maintenance of a level of systematic research appropriate to Britain's status in international science.

In many developing countries without a long established tradition of curiosity-motivated systematic research, there are few trained taxonomists employed in systematic biology. In developed countries, such as the United Kingdom and France, taxonomic institutions such as national museums are under considerable pressures to meet other public demands at the expense of long-range internationally directed taxonomic research (see v below). These pressures in individual developed countries, unless guarded against, are liable to result in a disproportionate global diminution in systematic information. Britain is a major contributor to the international effort and the Committee is urged to propose measures designed to maintain, at least, the research levels of the recent past.

- (iv) *Areas of systematic research and setting priorities:* In recent years, especially over the debate to determine research priorities in biodiversity studies, the international community has come to accept that it is not feasible to spread what little taxonomic research effort is available to make surveys of all organisms. The number and proportion of undescribed organisms is unknown and is certainly many times that of known organisms. As a result, it is anticipated that there will be concentrations of research in areas (both taxonomic and geographical) selected by scientists as currently possessing the greatest potential to yield generalisations, and those that are members of ecosystems of direct importance to human economies or are threatened.

When selecting areas for national research, it is to be hoped that developed countries like the United Kingdom will not only take into account their own internal needs, but also wider global needs which, by virtue of past effort, they are equipped to serve.

However, having selecting areas of research concentration, provision must also be made for the maintenance and continuing use of systematic collections resulting from past studies (see v below).

- (v) *Reference Collections*: Taxonomy is a “cumulative” science. Observations upon which hypotheses are based must not only be repeatable (often with emphasis upon characters previously regarded as unimportant), but the specimens upon which the observations are based must be capable of being compared and regrouped differently with fresh material. This feature of taxonomy places a particular (and special) burden upon institutions conducting systematic research. In most research institutes, science moves forward without any need to preserve the physical basis of past research. But in taxonomic institutions, past collections may seldom be discarded and must be preserved against deterioration, from physical or biological causes, for future use. This imposes costs independent of whatever research is currently being conducted.

In addition, collections made in former times are nowadays mostly unrepeatable because of environmental changes. Their disposal or neglect results in permanent loss to science. The national institutions of the UK are particularly rich in such collections.

Moreover, British institutions such as the Natural History Museum (London) and the Royal Botanic Gardens, Kew, have a special responsibility to international science because of the global nature of the collections of type specimens held by them. Types are the standards of reference to which the names of organisms are referred objectively. They are a by-product of any research which results in the definition of new species and subspecies. British collections are particularly rich in extra-territorial types upon which the research of other countries depends. Since types are the indispensable basis of biological nomenclature, they should be treated by institutions holding them as the property of science—and in their care as trustees (see International Code of Zoological Nomenclature Art. 72g, and Recs 72D-G).

An additional problem that the holders of widely representative collections face, results from the need to maintain the past collections in a form in which they are accessible to the scientists of the parts of the world from which the collections came. This requires not only proper maintenance, but also a range of curatorial expertise that may extend well beyond that required to meet local (ie national) needs and priorities (see iv above, and attachment C—Resolution 8).

Over the years, the international community has come to value greatly the capacity of the Natural History Museum (London), to maintain the international collections in excellent condition, and also to provide information on them, in a most cooperative manner, in response to requests. The perceived threat to the capacity of the Natural History Museum to continue its international service prompted the Union to approach its British national adhering member (the Royal Society) expressing its concern (letter attached B).

- (vi) *Impact of new methodology*: New methodology—especially the development of techniques employing molecular biology—has imposed new strains upon institutions supporting systematic research. Provision must be made for tissue banks and culture collections which creates a range of maintenance and technological difficulties that can only be overcome with large and ongoing expenditure in both collection technology and differently trained personnel. Despite these additional costs, the new methods open opportunities of advance undreamed of only a few years ago and that no modern taxonomic research institution can afford to ignore.

In the case of systematic microbiology, modern science depends upon these new methods.

Currently, the Union is anxious to encourage the development of the new methods and supports the recent resolution of the International Congress of Systematic and Evolutionary Biology—ICSEB, (a Scientific Members of the Union) in this regard (see attachment C—Resolution 9).

- (vii) *Current Institutional base for taxonomic research in the UK*. IUBS has no comment to make on the appropriateness of present arrangements beyond observing that several great British national institutions (such as the Natural History Museum and the Royal Botanic Gardens, Kew) have given wonderful service to international science over more than a century. The recent widespread reaction to proposals that seem likely to reduce the effectiveness of these institutions in their former role is a measure of the value placed on them internationally.
- (viii) *Payment for systematic research*. IUBS appreciates that under the “user pays” principle, the question as to who pays for taxonomic research raises difficult issues but these are not fundamentally different from other issues that face governments when allocating priorities to financing infrastructures when benefits are widespread and principal users are not, in the main, identifiable. Since the “useful” product of taxonomy consists of infrastructure used in

information systems throughout science (and often developed ahead of the need), the Committee is asked to accept that, in the main, the ongoing service can only be provided by ongoing support from the public sector. In a few cases, such as environmental impact studies, and specific pollution control or pest control researches, industry or public agencies may commission taxonomic studies, but funds from these sources cannot provide for the overall development of infrastructure and the ongoing maintenance of taxonomic collections.

IUBS can give little guidance as to whether the United Kingdom might hope for international assistance to help it to defray the costs of its off-shore research. No member of IUBS, hitherto, has considered proposing launching an international contributory program to fund systematic research to spread the load more evenly across the member countries. From experience of international agencies and their funding, it is unlikely that such a proposal (that would require the commitment of ongoing expenditure by such agencies) would be received with enthusiasm at a time at which there is pressure to reduce ongoing overheads.

Voluntary contributions in support of bionomenclature have been sought by IUBS in the past. Some countries (the UK being an outstanding example) have been very generous, but the level of support received in most cases was, at best, little more than a token.

The greatest financial problem results from the fact that the countries in parts of the world where information is least (and most urgent to acquire) are those who can least afford to pay.

Expressing an international viewpoint, IUBS would hope that the developed countries (such as the UK) would continue to function at least at current levels. Moreover it is hoped that the governments of the developed countries will continue to recognise their responsibilities to developing countries (even though these may no longer be imperial responsibilities) and to continue to promote world wide systematic studies.

While there seems little hope of establishing an ongoing international funding arrangement in support of systematics or any of its branches, we would not rule out the possibility of internationally funded programs with limited objectives. The currently proposed International Biodiversity Program may provide such an opportunity. The Committee might explore with the Royal Society whether or not it would be appropriate for the UK delegation to make such a proposal.

- (ix) *Teaching in systematics:* In the experience of the Union there are two different aspects to this question—both covered in IUBS resolutions.

Firstly, there is great need for promotion of taxonomic studies in universities. In zoology in particular, courses in the principles and practice of taxonomy are a rarity nowadays.

Secondly, there is need for much wider general understanding of the role of systematic science (and taxonomy)—and the excitement of systematic research. Today the taxonomist's image is deplorable—unfortunately, even among professional colleagues. IUBS has asked its Commission on Biological Education to give this matter priority.

- (x) *What can be learned from other countries:* If the Committee enquires, it will find that there are pressures that will have the effect of reducing effort in taxonomic (and hence systematic research) in all developed countries. This is largely because government funding is tight everywhere, but also because of shifts in priorities in taxonomic research institutions. These institutions are often museums and botanic gardens and have expanding public programs to accommodate within the same budgets. The development of basic infrastructure is seldom regarded as urgent, as compared with other pressures. Also for reasons given above, systematic research is seldom funded directly by the private sector.

Despite this somewhat gloomy picture, in a number of developed countries there are good examples of very effective programs of long-term importance. For instance, work being done in support of international programs of biological nomenclature in the UK is outstanding and is a fine example (i.e. the participation of the Royal Botanic Gardens, Kew, and the International Mycological Institute in the current program to improve stability of plant names; and of the Royal Society and Natural History Museum in supporting the Secretariat of the International Commission on Zoological Nomenclature). Despite diminishing public sector funding, examples exist of countries that have recently developed national organisations charged with increasing knowledge of systematics and to maximise benefits from public expenditure. Australia and Costa Rica provide examples of different approaches that the Committee might consider. But it must be emphasised in these cases the governments have approached the problem of providing national taxonomic infrastructures, and not the provision of international services of the sorts provided in the past by Britain and the United States through the Natural History Museum, the Royal Botanic Gardens, Kew, and the Smithsonian Institution.

With regard to programs of deliberate aid to an overseas country, the Committee might, enquire from the Smithsonian Institution about current programs directed to improving the effectiveness of taxonomic sampling techniques in Central America. There are other examples. The Committee might consult Dr Peter Raven of the Milwaukee Botanic Garden and Dr F H Talbot of the US National Museum of Natural History, if it has not already done so.

Evidence from Lancashire Polytechnic

(i) *What is the utility of systematic biology research?*

There are two levels of systematic research in biology:—

1. Describing new species. This requires specialist knowledge for each group of animals and plants. This is essentially naming and cataloguing every living organism so that other scientists can recognise the same species if they find it. It requires considerable technical competence and currently only about one and a half out of a possible thirty million animals have been formally described.

2. Research into the relationships between different species. This can be of purely evolutionary interest, or it may have direct relevance to some applied biology problem. For example parasitic insects are often used in biological control of pests. Sometimes one species is a good control agent while another very similar one is not. Sometimes one subspecies is good while another is useless, so the systematist is required to sort out confusion that can arise if these relationships are not known. Systematists are also important in sorting out the different strains or species of microorganism which may be important medically or agriculturally.

Systematic research is important as indicated in 2 (above) in medicine, veterinary science, fisheries, agriculture and other forms of land use (ecology). It is also necessary to some aspects of the rapidly developing science of biotechnology.

But such research can only be satisfactorily carried out if the relevant species have been properly described (1, above), so species description is important in its own right.

(ii) *Is the level of UK research appropriate. If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?*

Systematic research began to decline 20 or so years ago together with ecology. In recent years the need for more ecological research has become apparent but there has been no resurgence in systematic research activity. Indeed, there have been cutbacks in the only British museum that conducts a major programme of systematic research, namely the Natural History Museum in London. Compared with national museums in other countries of Western Europe, the level of funding for systematic research is very poor, and NERC gives few research grants to Universities or Polytechnics for systematic research. Judging an appropriate level of research is not easy, but it is hard to justify on biological grounds the cutbacks that have occurred over the past 10–20 years. In financial terms systematic research can be more cost effective than the more expensive areas of biochemistry or physiology (although it is similarly expensive where it uses techniques from these disciplines).

(iii) *Is UK research in the right areas? Are there guiding principles which could help a “national policy” within which the existing facilities would operate, eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?*

On the “national” scale Britain should attempt to ensure that systematic research encompasses all major taxa of living organisms. Taxa of economic interest are not necessarily of greater importance than other groups, since they may attract commercial funding, and in any case it is not always easy to predict which will one day prove to be of economic interest. Only by having a broad systematic coverage is it possible to ensure that ecological studies of a diverse range of habitats are adequately supported by systematic research. This means that support for systematists needs to be spread wider than the Natural History Museum and a handful of research institutes and Universities. The cost of expanding support for systematic research is not as high as that for most other areas of biology.

(iv) *What is the extent of our need for reference collections including foreign material (type collections, living culture collections, etc) as a base for systematic research? Is provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?*

The majority of countries in the world have wholly inadequate funding to support systematic research or indeed curatorial facilities for systematic material. This is especially true in the tropics where the overwhelming majority of species occur, but where deterioration due to moulds, bacteria and insects means that skilled and well funded museums and herbarium personnel are even more important than in temperate countries. Britain also houses some of the most important collections of systematic material in the world, and as a comparatively wealthy country, it therefore has responsibility for caring for and researching into this material. It also has to take a share in carrying the burden of systematic research for third world countries where diversity of species is high but funding low. In view of the current rapid destruction of the most diverse of all ecosystems, tropical forests, there is urgent need to carry out more systematic research on the organisms that live there. Britain should aim to play a full part in this research. Currently some sections of the collection held in the Natural History Museum are in a “care and maintenance only” condition. What is needed is active collection and description of material followed by preparation of management plans to ensure conservation of the most appropriate areas.

- (v) *What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research taking cognizance of the full range of new developments in this field?*

Modern methods of systematic research involve sophisticated biochemical techniques as well as computerised databases. These are expensive, but are currently only being used in a handful of groups of animals and plants (principally where there is economic relevance). While these methods need to be developed and expanded, it should not be at the cost of reducing funding for basic systematic description of new species.

- (vi) *Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?*

There is no objection to the current practice of having major institutions housing much systematic research (Museums, Kew Herbarium, NTCC for bacteria, IMI (Kew) for fungi, etc), indeed this is probably cost effective. Additionally, there are many individual systematists throughout the country in Universities, Polytechnics and Research Institutes. Unfortunately funding for all this work has declined in recent years. The NHM in particular has suffered major cutbacks and several areas of research have been curtailed. This trend must be reversed if Britain is to carry out the work outlined in (v) above, but we have no strong views on whether OAL or DES should be responsible.

- (vii) *If research is to be continued, who pays?*

It would be very valuable if the UN could coordinate and fund systematic research worldwide, but Britain should be in the forefront urging such a programme. However, it must be accepted that under such a programme the main beneficiaries would be tropical third world countries, and Britain would be more likely a net donor than a recipient of funds. So it is essential that a secure and sustainable funding is found from Government sources for this work. Substantially more is required than is currently available. The level of provision should be substantially *more* than was available 15 years ago (before the cutback of the 1980 s). The role of industry in this funding is likely to be small because it is more interested in short term financial gain or in patenting particular microorganism constructs. There are extensive culture collections of microorganisms in industry, but these are not available to the public or the wider scientific community. If industry is asked to contribute there would need to be a clearly defined agreement specifying what information the systematists would be expected to make available to the sponsoring industry, otherwise industry may see little gain in its contribution.

- (viii) *Is teaching adequate?*

Emphatically not. But until there is a major expansion of employment of systematists, it is unlikely that a course at graduate or undergraduate level would attract students.

- (ix) *What can we learn from abroad, especially the USA?*

The USA and some West European countries have far stronger support for systematic research than does Britain, and consequently their influence in the scientific literature and in the forefront of research is now well ahead of that of Britain.

Evidence from Leicester Polytechnic

Thank you for your letter dated 22 April 1991 in which you sought comments for the House of Lords Select Committee on Science and Technology. My comments below are numbered in accord with the system used in the original letter from the Clerk of the Sub-Committee which is considering this matter.

- (i) Linnaeus said "All knowledge of an organism is worthless until you tell me its name". In other words work on an organism can neither be repeated nor applied unless the organism is identified precisely. Systematic biology is the foundation upon which the framework for pure and applied research is constructed. The rate of publication of new data indicates that the elucidation of systematic relationships is far from complete and, it may be argued, can never be completed. There is a need to ensure that the world's biological diversity is maintained. Systematic biology has an important role in ensuring that the diversity of the gene pool is recognised/established and preserved.
- (ii) A wide range of regulations govern research and development work in the Department of Applied Biology and Biotechnology at Leicester Polytechnic. The Applied Ecology work benefits from the Wildlife and Countryside Act (1981) for example. However, the major relevance to our work is with regard to our research and development in biotechnology. The EC and US Patent Offices allow patent cover of living organisms. It is essential for biotechnological development and technology transfer that the technology is protected by patent: it is most

unlikely that any commercial enterprise would justify the expenditure involved in bringing a product to market unless the company's position was protected. For protection to be granted through patenting, any organism which forms part of the process must be adequately described. There is thus a requirement to ensure that systematic research enables users of organisms (ex culture collections or newly isolated) to adequately describe them.

- (iii) There has been a worrying decline in UK Systematic Biology Research particularly during the last decade. This will disadvantage those who apply the results of the work. Reinforcement of the research base in this area must underpin much of the work in "competing biological disciplines".
- (iv) The paucity of funding for UK based systematic biology research has inevitably introduced large gaps in what was once a prestigious and high profile area. Certainly, the development of a "national policy" to reinforce our present position should draw on information regarding an ecological/economic importance of groups of organisms and the existing spread of expertise and quality of resources available in the country.
- (v) Such collections are the basis of much systematic work. The erosion of provision for their storage and curation is a source of very special concern. The fact of the holdings identifies a particular responsibility to the world scientific community.
- (vi) There is some doubt whether new molecular biological techniques are being exploited as fully or as quickly as would be appropriate. Systematic biology research should give more emphasis to an extension into analysis of populations and of the individuals themselves. The newer techniques of DNA fingerprinting and image analysis have particular utility in these areas. The potential for use of expert systems has barely been realised.
- (vii) The institutionalised base has not become inappropriate but the rapid reduction of funding has challenged much which is of value. It is difficult to imagine why the DES should not fund the NHM.
- (viii)(a) An international programme of collaboration in this area has enormous attractions not least because funds could be drawn from supra-national bodies.
- (b) The movement of funds from other areas to remedy deficiencies in support of systematic biology research is not attractive. Government support of research in general and biology research in particular is now quite inadequate.
- (c) Support by industry would be warmly welcomed but in this area particular concerns attach to the possible distortion of activity and compromise of objectivity.
- (ix) Examination of curricular and experience of students emphasises the low level of appreciation of the vital role of systematic biology in courses at all levels. Students routinely enter higher education lacking:
 - (a) any idea of how to use taxonomic data about a species to predict its properties/"life-style", etc.;
 - (b) any familiarity with the range and pattern of diversity in metazoa. Hence, such disciplines as toxicology are particularly disadvantaged by the vague perception that all animals are like white rats but vary in size. The range of strategies for dealing with the same basic problem tends to be unknown as is the extent to which features of mammalian physiology are atypical of metazoa as a whole. This situation determines poor work in toxicology, pharmacology and ecology. Such fundamental defects of understanding ensure that, for example, the standard response to oil spills on sea and shore does more damage than the oil itself.

If school courses ensure that the vital role of systematic biology becomes apparent to students, then there is no excuse for higher education programmes continuing to fail in this area.

Supplementary Evidence from the Linnean Society

STATUS

1. Systematic Biology has suffered great losses, but not because of its excessive fragmentation; rather, because of competition with other more laboratory-based disciplines in biochemistry and molecular biology. It is undervalued through a misunderstanding of its basic importance as a foundation to all other biological disciplines.

2. See 1 above. It is a distinct scientific discipline (see my report).

3. "Amateurs" form a small but significant fraction, concerned mostly with alpha-taxonomy (not with experimental or laboratory-based studies); they are certainly fewer than 50 years ago.

4. Data storage and recovery have enhanced the "wide-experience-plus-memory" aspect of biosystematics, enabling biosystematists to benefit from computer data banks and so to make better use of their wide experience and understanding.

5. There are still large numbers of systematic papers carried in journals, possibly slightly increased, but decreased in proportion to those of other scientific disciplines.

UNIVERSITY LINKS

6. Collaborative links between universities and national institutes have decreased probably, due to the diminution of biosystematists both in universities and national institutes—also the difficulty in obtaining funding grants. Closer links could be effected by increasing the number of biosystematists and, particularly, research funding grants both in universities and national institutes.

REGIONAL FUNDING AND PRIORITIES

7. The system of passing NERC taxonomic publication grant funding for administration by the Linnean Society is most valuable. This might be extended to cover research funding also. Perhaps SERC and Royal Society funding for biosystematic research might also be administered by the Linnean Society, or by some other independent body.

8. See 7 above. There is great competition for research funding in times of financial stress, as at present. Few committees have taxonomists on them and thus are less well able to evaluate taxonomic *versus* non-taxonomic research grant requests.

9. The Linnean Society Grants Committee can only give priority to systematics research in a very limited field through shortage of grant funding. Its policy is to support good research wherever possible according to clearly defined priorities, and it could play a more significant role in the future if more funds became available.

10. U.K. institutes (or those of any other countries) cannot possibly hope to maintain research collections and systematic expertise in all groups of organisms. Priorities are determined partly by the collections available, partly by perceived scientific or conservation needs, and, of course, by gifted individuals and the interests and expertise available in this country.

11. This is an extremely difficult question to answer. It would be better to try to restore the balance by providing more money overall and by reducing slightly the funds previously allocated to other disciplines, thus providing a better overall balance.

12. The *organisational* change I would advocate is to fund systematic biology research separately from other disciplines or to ensure that at least one systematic biologist was appointed to each relevant committee (see 7-9 above).

TRAINING AND COURSES

13. The problem here is lack of research funding and job prospects. A career structure with more posts available in museums, research institutes and universities concerned with systematic biology would have no difficulty in drawing students into this subject, in our view.

LINNEAN SOCIETY QUESTIONS

14. Professor M F Claridge's report deals with this question.

15. Curation and research are indissolubly linked, if by curation we mean the arrangement and classification of such a collection. We have an active research project in progress entitled "The Linnean Plant Name Typification Project". This is funded by the Natural History Museum, the American National Science Foundation, the Missouri Botanical Garden, the Swedish Linnean Society and NATO. It involves active research on the Society's Linnaean Collections and on others from relevant museums and institutes.

It should be understood that if by "curation" we mean routine technical activities, such as repairing damage, writing labels and general maintenance, such activities can be undertaken by well-trained technicians.

16. Revisionary work on Flora Europaea is being integrated with European taxonomic expertise and at the appropriate time a European-wide funding initiative will be put forward.

Evidence from Liverpool Polytechnic

W G Hale BSc, PhD, DSc, CBiol, FIBiol, Director of School (Professor of Animal Biology), Ian D Hodkinson BSc, PhD, DSc, Reader in Entomology (with major interest in systematics), Ray Gibson BSc, PhD, DSc (Professor of Marine Invertebrate Systematics)

The following responses correspond numerically to the sectionalised questions posed in the original request for submissions.

Section (i)

1. Systematics is the basic activity that underpins the whole of biology. It is the structural framework on which biology is built.

2. Each species of living organism must have its own unique name and identity which serves as a point of reference and which allows biologists throughout the world to recognise that species. It is the function of systematic biology to provide this name and identity and to classify organisms into similar types, based on their characteristic features and biologies.

3. A good classification system, based on a sound taxonomy, has great predictive value. It allows the biologist to understand the relationships between species, to the extent that the characteristics and properties of newly discovered species can often be predicted from those of known related species. The classificatory systems produced by systematic biologists are much more than systems for naming plants and animals: they are the depositories of knowledge on all living organisms. They incorporate information on biology, physiology, ecology, zoogeography etc., etc. Without these systems all biological information is useless as it cannot be applied to any known fixed point of reference.

Section (ii)

4. The need to specify particular organisms is fundamental to all branches of biology that deal with whole organisms or the organs and tissues derived from whole organisms. The biologist needs to know the identity of the organism on which he/she is working. This is true of a range of disciplines from ecological field studies through disease control to the propagation of cell lines in the laboratory. Intellectual property rights is, in many respects, a separate ethical question. Does the individual biologist have the right to "copyright" a living biological organism? I suspect this is a subject on which biologists will remain divided.

Section (iii)

5. UK research in systematic biology is poorly funded and the resource base is suffering constant erosion. We are now reaching the point where large gaps are developing in the basic systematics expertise available to biologists. For example, several groups of important pest species of insect, such as aphids and true flies, lack experts who can identify the British species with accuracy.

6. An appropriate level of research support would be one that (1) allowed existing classificatory systems and specimen collections adequately to be maintained, (2) permitted goal-centred research on specific identified problem areas and (3) allowed time for the introduction of innovative uses of information technology designed to aid the future storage and recovery of information on living organisms.

7. Thus it is necessary to nurture and maintain a broad spread of systematic expertise that is capable of acting efficiently to meet the above criteria. Systematics must leave behind its Cinderella image of musty museum taxonomy, embrace the new technologies, and take its place alongside newly developing fields at the cutting-edge of biology. There must also be recognition by other biological scientists of the crucial role that good taxonomy plays in enhancing the value and application of their work.

8. It would be a grave error to concentrate exclusively on goal-orientated systematic research. The most pressing problems most frequently arise in the least expected areas. It requires the stability and flexibility of a well-maintained classificatory system to deal with these unexpected problems.

Section (iv)

9. It is almost impossible to define "right areas". What are perceived right areas? Almost by definition the right areas are constantly changing as new problems develop. What is required is a basic system of operation that is capable of responding flexibly and rapidly to needs as they arise. The success of any such system must ultimately depend on a reliable well-maintained data base/specimen collection, supported by a well-trained staff.

10. Systematics is not easy. It takes time for individuals to develop expertise and get to know a group of organisms. It is often difficult for the lay person to grasp the fact that there are probably in excess of 5 million species of organisms, of which even the most knowledgeable person can only deal with a small fraction. Total coverage requires a wide range of diverse expertise.

11. Ecological research requires, at times, the correct identification of nearly all groups of living organisms. Economically important groups of pest species are numerically more restricted but new pest species often arise unpredictably from within groups not previously considered pests. There is no way that this can be foreseen.

Section (v)

12. Reference collections, containing named type specimens, are the cornerstones of systematic research. The preserved specimens fix for all time the known identities of species. The working code for the description of species, drawn up by the International Commission on Zoological nomenclature, states that type specimens must be designated for all new species and that these specimens should be placed in a safe repository where they will receive adequate curation. The material is readily available for examination by the scientific community. Systematic research without reference collections would be like mathematics without numbers.

13. Biological organisms do not recognise international frontiers. Often the closest relatives of British species are found abroad. To understand the systematics of the British species it is necessary to understand their position within a global context. Systematic collections based on a single country are usually of limited usefulness and good systematic classifications synthesise information drawn from across the world fauna or flora.

14. We are becoming increasingly concerned that the level of resources available to maintain systematic collections at institutions such as the Natural History Museum are inadequate and that the structure of systematics and its ability to service other areas of the Biological Sciences is being seriously undermined.

15. Historically Britain was a world leader in the development of systematics. In consequence, the major British Institutions became recognised as major centres of excellence. This has led to institutions such as the Natural History Museum becoming the major repository for type specimens collected throughout the world. Generations of scientists from many countries, particularly the Commonwealth, have deposited their type material of plants and animals in our national collections in the belief that the responsible institutions would curate the material and make it available to other scientists for study. The collections thus represent stability and, perhaps most importantly, continuity. This is particularly relevant for developing countries where such desirable ideals are often unattainable within their own shores.

16. The major collections of animal and plant materials housed in institutions such as the Natural History Museum and the Royal Botanic Garden represent the most complete sets of named living organisms available to the scientific community. Scientists travel from around the world to consult these collections and to compare specimens. For many developing countries these are the only collections available and the only places where the appropriate systematic experts can be consulted. Britain, therefore, has a particular responsibility to the wider world scientific community. Thus, for example, successful pest control in many African countries depends ultimately on the expertise of British scientists built around our national collections.

Section (vi)

17. Systematic biologists in the UK have been slow to exploit new technologies. Like many institutions, those involved in systematics develop their own inertia to resist change. Frequent reassessment of scientific objectives and methods is highly desirable and mechanisms should be established to achieve these ends. However, stability and continuity must be maintained. Furthermore, for systematic institutions to function effectively, change must be motivated by clearly defined scientific objectives and not by short-term political or financial expediency.

18. If some systematic biologists can be released from routine tasks and appropriate levels of support are made available, then there is huge scope for the development of expert systems and related data bases, drawing together the vast amounts of information available to the scientific community. The possibilities are almost limitless. The end-products are highly desirable. We, as practitioners of systematics, would relish the opportunity to have the time and support necessary to develop such systems for our own particular groups of organisms.

19. Significant new methods for studying the classification of organisms are being developed but are not being used to their full potential, owing to lack of support. Such methods include the use of recombinant DNA technologies.

Section (vii)

20. To maintain the stability and continuity mentioned above it will always be necessary to provide a constant stream of funding, at an adequate level, to our major systematic institutions to enable them to curate their collections maintain an information base and conduct research and revisionary work on their material to the benefit of the overall classificatory systems. At present the funding base appears insecure.

21. Complementary funding for work in specific areas of systematics should be provided in the form of grants through the Research Councils for particular projects of high scientific merit. These would be subject to open competition and would be available to staff of the major systematic institutions as well as the staff of Polytechnics and Universities.

22. The decision to place the NHM under the responsibility of the OAL was, to many scientists like ourselves, almost incomprehensible. It suggested a lack of understanding of the role of the NHM in British Science and a trivialization of its scientific purpose. The NHM should be under the DES.

Section (viii)

23. The cost of systematic biological research in the UK is small when compared with capital intensive areas such as astronomy and particle physics. In many respects it is a flagship for Britain's responsible role in world science in that it provides tangible benefits to a wide range of recipients, from the agriculturalist in Africa to the multi-national Corporation involved in tissue culture or environmental assessment. It is, however, at core, a basic science that requires baseline funding if it is to provide the required services. Such funding must come from the science budget. Systematics is too important for science in general to be reliant on insecure contract funding.

24. Perhaps one way to make people realize the significance of systematics (this suggestion is only half-serious) is to permit copyright to be taken out on the names of all described species and to charge royalties on the subsequent use of the name. Some unloved systematics biologists would become rich very quickly!

25. There is some possibility that major world institutions might cooperate to coordinate systematic coverage and prevent major overlaps. This would, however, prevent each from offering a complete general service.

Section (ix)

26. Systematics is often seen by students as an unattractive option compared with say some of the new developing biological technologies. It is seen as dull and uninteresting and, given free choice, few students choose it as an option, although often those that do often become deeply interested. This negative perception results in part from impressions created at school and students often do not fully comprehend the scope and excitement of modern systematics at the highest level. Much work needs to be done, through the development of attractive courses, to draw the ablest students into systematics.

Section (x)

27. There is much to be learned by looking abroad—much of it negative! Britain has been, and probably still is, a world leader in systematics. Overseas scientists look to our institutions, despite their faults, as being shining examples of good practice and enlightened investment in worthwhile research, very often in stark contrast to their own countries. Heed should be taken of the way in which gradually eroding investment in systematic research at the United States National Museum, Washington DC, is undermining its function. The consequences are that the collections are now poorly maintained, the data bases are often incomplete, the necessary expertise is lacking to provide routine identification and low staff morale, linked to a lack of new blood, is restricting opportunities for innovation.

Evidence from the Council of the Malacological Society of London

The Malacological Society of London provides the largest forum for malacology (the study of molluscs, which include snails, slugs, clams and squid) in the United Kingdom and is responsible for organising symposia and publishing the *Journal of Molluscan Studies*. This is one of the most prestigious of the international journals devoted to malacology. Through these activities the Society is aware of current trends in malacological research including systematics. On behalf of its membership the Council of the Society wishes to make the following response to the questions posed by the Select Committee.

1. What is the utility of systematic biology research?

Systematic biology provides a common theoretical framework for the understanding of the diversity and evolution of all life forms both living and fossil. Through taxonomy it provides a common framework which permits communication between all branches of biology and between biologists of all countries. Given the current concern with conservation, systematics has a central role in the establishment of a global inventory of species.

This is especially important in malacology as molluscs are the second largest phylum in the animal kingdom. They are significant to man as a source of food, as hosts of medically important parasites, as agricultural pests and as a source of raw materials such as shell. They are one of the major components of the food chain in marine ecosystems. Molluscan shells are prominent in the fossil record and are therefore important in evolutionary studies and as stratigraphic markers. Without an adequate systematic base all research in these areas is jeopardised.

2. *Does the need to specify particular organisms in connection with eg intellectual property rights, regulatory provisions etc, impinge upon your work?*

All systematists involved in providing identifications for legal or commercial work are aware of the necessity of accuracy inherent in the regulatory provisions. Examples are ecological monitoring related to pollution, conservation and planning; wild life protection under CITES; and in pest control in agriculture. The lack of systematic expertise, or of access to systematists, can render the above activities either impractical or meaningless.

3. *Is the level of UK research appropriate? If so, how does one determine an appropriate volume? How does it rank with competing biological and other disciplines?*

Systematic research on Mollusca in the UK is decreasing as evidenced by the submissions to our journal from UK scientists. The appropriate level of research can be assessed both from a British and an international perspective. Although the taxonomy of the British fauna is relatively well understood at the species level (except for the deep sea), there is enormous scope for phylogenetic and population-level studies. The Mollusca offer considerable opportunities for investigating the mechanisms of speciation and the relation between genetics, morphology and the environment. At the global level, the systematic collections held by UK museums are arguably the most important of any country of the world. Despite the potential use of these collections in studies of global diversity, there are at present insufficient systematists in the UK to make full use of this resource.

By comparison with other disciplines systematics is gradually being excluded from university research in favour of suborganismal biology (eg molecular biology).

4. *Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which existing facilities would operate eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?*

There is no framework for systematic research in the UK. Many systematic studies are a peripheral result of ecological or applied research. Expertise is at a low ebb in the UK, resources are generally poor and the combination of these factors renders a "national policy" based on existing facilities of little value.

It is essential to develop the theoretical and experimental aspects, as well as to fulfil the demand for taxonomic studies and the production of identification manuals.

To base systematics solely on economic criteria is generally detrimental to the theoretical studies which underpin applied usage. Given the increasing demand for data on biodiversity loss and for ecological monitoring of industrial developments, both at home and abroad, there must be an increase in systematic studies. It should be stressed that systematic studies by their unifying nature, can rarely be assigned to limited geographical areas or to parts of a taxonomic group. They frequently involve monographic revisions which can take many man-hours to complete and as such are hindered by the "quick result" syndrome now so prevalent in UK research.

5. *What is the extent of our need for reference collections including foreign material (type collections, living culture collections, etc) as a base for systematic research? Is their provision for their storage and their curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?*

Reference collections are essential to systematic studies and also have a role in the making and checking of inventories for conservation biology and ecology. Collections should not be regarded as a static entity but must cater for current needs and developments. In malacology, collections have primarily been of shells only, but there is now an increasing demand for the use of anatomical and molecular characters which the current collections generally cannot fulfil. The developing awareness of population differences and ecophenotypic variation also necessitate the development of reference collections.

As a result of its historic role in systematics during the era of the building and exploration of the empire, the museums of the UK have uniquely rich and important holdings of type and figure material. Such material is fundamental to systematics and nomenclature, and as such must permanently be made available to the world scientific community. Furthermore, much of this historic material is from regions where the fauna is now endangered or extinct. It is therefore essential that sufficient resources are devoted to its curation and long-term preservation.

Our obligation to the world scientific community, by virtue of these collections, should not be regarded as a burden, but as an opportunity for collaborative projects and research. Repatriation of specimens cannot be considered. In most cases adequate facilities for their storage are not available in the country of origin. Moreover, there are many advantages in centralising global systematic research in a few large institutions, because of the comparative and comprehensive nature of the work.

6. *What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research taking cognizance of the full range of new developments in this field?*

New practical methods range from DNA sequencing to computer-based cladistic analysis. The former is an expensive technique and should it become a standard it would probably be beyond the reach of many research groups. In such cases some pooling of resources would be valuable. The introduction of cladistics has seen sporadic acceptance in the UK, which is primarily related to the lack of teaching of systematics. The adoption of new methodologies consequently suffers from the low status of systematics in the UK. Databases on collection holdings appear to be sporadic and are primarily inventory systems for those museums using them. Direct use of these for systematic research in a UK-wide framework is not possible. The establishment of a UK database of systematic collections would appear to be well beyond the current manpower resources of museums.

7. *Is the current "institutionalised" base of much of the research appropriate? Is their funding secure? Should OAL or DES be responsible for the NHM?*

The Society feels that it cannot comment upon this.

8. *If research is to be continued who pays?*

The Society feels that it cannot comment upon this.

9. *Is teaching adequate?*

No. The teaching of systematics has gradually been eroded and excluded from university syllabuses in favour of suborganismal biology. This has not only resulted in fewer systematists being trained, but also the level of systematic expertise of the biology graduate has declined. Without a good grounding in systematics, those students entering community ecology, environmental and conservation studies are now severely disadvantaged. This lack of training can jeopardise the value of monitoring studies and the systematic accuracy required by regulatory provisions (see section 2). The lack of training has not only resulted in decreasing research but also has affected the service sector of taxonomy, such that there are fewer and fewer experts available to give advice to the increasing numbers of inadequately trained biologists.

10. *What can we learn from abroad, especially the USA?*

The status of systematic biology in the USA has been under review and the problems resulting from lack of systematic research have been recognised not only within the USA, but globally. The role of the NSF appears central to the US response and this could be examined.

Letter to the Chairman from the Secretary to The Linnean Society of London

I have been thinking about your question yesterday about how to get systematic biology a better position in the biological pecking order. I started life as a chemist, with no biology at school nor in my first university degree. In 1965, I became a lecturer in biology at York, setting up a new department.

For a few years, we ran an obligatory 1st year course on biological diversity. It was taught by most of the staff, each of whom had some knowledge of particular groups. The result was a ragbag, unpopular with students, who saw no theme, and with staff, who were embarrassed by having to fail students who might be more than adequate in biochemistry or genetics, the other 1st year programmes. Eventually the course was dropped.

At the Polytechnic of Central London, where I became Head of Life Sciences in 1974, there was a biological diversity programme in the 1st year. It was taught in the same way—lots of staff, some part-time. Again, it was unpopular with students and was substantially modified to an ecology course.

Newer taxonomic procedures (and we do have a meeting in April 1992 on the old vs the new taxonomy, which you will be welcome to attend) do offer the prospect of leading edge technology, which tends to appeal to students. Jack Hawkes told me that he taught taxonomy by reference to its use, its economic importance and its problems. The systematic work was left to practical classes, which were popular. Few people have the knowledge and confidence to do that.

Newer methods of taxonomy based on DNA isolation, restriction enzymes, polyacrylamide electrophoresis and maximum parsimony, with all the problems, might encourage students to believe that systematic biology is not a backwater. These methods might be applied to fossils and other extinct organisms and to clinical work in parasitology. And what are we to make of genetically engineered eukaryotes? All this is heady stuff. Comparisons with morphological methods would be necessary. I

cannot help but think that this would enhance the detailed study of systematic biology. It would, of course, be a good deal more expensive, but I do not think that modern technology can, or should, be ignored.

I must emphasise that these ideas are entirely my own.

John Marsden.

Evidence from the Ministry of Agriculture, Fisheries and Food

Q1. What funds, both in real terms and proportionally, were devoted by MAFF to systematic research and/or training at MSc and PhD levels during the years 1989/90 and 1990/91? Is MAFF satisfied with these figures? Are these figures likely to increase, decrease or remain the same in the immediate future?

A: MAFF's total R&D spend in 1989/90 and 1990/91 (excluding grant-in-aid to RBG, Kew (£11.6 million and £13.4 million (estimated out-turn for 1990/91)) amounted to £108 million and £113 million. It is difficult to estimate the proportion of these funds devoted to systematic research. The amount for systematic research *per se* has been small but some funding may have been needed to support statutory requirements and research commissioned on wider areas. Some £3 million of the grant-in-aid to RBG, Kew was devoted to Systematics Research.

With regard to training for MSc and PhD students, funding for the MAFF Postgraduate Studentships Scheme supported 147 students (at a total cost of £900K) in 1989/90 and 141 students (£1,000K) in 1990/91. None of the projects in either year was directed solely towards systematic biology research but it was implicit that training in the identification of organisms relevant to individual projects would be needed and provided.

Future funding by MAFF to RBG, Kew will be sufficient for RBG to meet its obligations under the National Heritage Act 1983. Planned MAFF provision for CABI in PES is for £660K in 1991/92, £676K in 1992/93 and £693K in 1993/94. The future provision for the MAFF Postgraduate Studentships Scheme is also subject to PES.

Q2. What financial support does MAFF give (directly or by grant-in-aid) to the bodies set out in part three of their written evidence? Is it possible to distinguish between expenditure on maintenance of collections and on research? Is expenditure likely to be maintained for the future?

A: The estimated out-turn for MAFF's grant-in-aid to RBG, Kew in 1990/91 is £13.4 million, of which some £3.0 million can be attributed to systematics research. The PES provision for the grant-in-aid in 1991/92 is £15.5 million; the allocation to systematics research will be at the discretion of the Board of Trustees.

For CABI, 85 per cent of the income comes from sales of information, products and services. The UK subscription to CABI is paid predominantly by MAFF, with DANI making a 2½ per cent contribution. The PES provision for 1991/92, 1992/93 and 1993/94 is for £660K, £676K and £693K. The MAFF subscription contributes to the totality of CABI's activities and it is difficult to specify the proportion spent on systematics research as distinct from the maintenance of collections.

Q3. Does MAFF ever commission research into systematic biology and from which organisations?

A: MAFF supports research into systematic biology directly through its grant-in-aid to RBG, Kew. It also provides indirect support through its subscription to CABI.

In addition, through its research commissions with, for example, AFRC and ex-AFRC institutes, universities and in-house establishments, MAFF supports scientists who may need to investigate aspects of the identification especially, but possibly also of the classification and inter-relationships, of organisms.

Q4. Is MAFF satisfied that the state of systematic biology research and training as a whole in the UK is adequate for their present and future needs?

A: Broadly speaking, MAFF's present needs are being met and MAFF's in-house training activities do contribute to the meeting of its needs. There is a feeling in MAFF that more in-house training is needed now than used to be the case but this increase would be difficult to quantify. Furthermore, the training that needs to be provided competes for resources with other MAFF objectives and consequently is less than ideal.

MAFF will continue to rely on universities, polytechnics, colleges etc to provide training in systematics for students. MAFF does not wish to see in-house requirements for training increase continually.

Q5. It is often stated that systematic biology suffers in the level of funding available, by comparison with other areas of science. Would MAFF agree and is it justified?

A: Although it has no supporting figures, MAFF's perception is that traditional, morphological taxonomy has suffered in recent years. However, it is clear that interest, and thus funding, in taxonomy has been re-kindled in recent years by the application to it of novel molecular methodology and techniques.

Q6. *What is the total number of staff in MAFF institutes who are largely concerned with taxonomic work? Has this number changed significantly during the last five, ten years?*

A: The numbers of staff identified depend very much on what is included as taxonomic work; for example, the inclusion/exclusion of all work on gene-sequencing, which may have some implications for taxonomy, would affect the total considerably. In addition to those involved in the identification and classification of organisms as part of wider investigations, MAFF devotes some 40 man-years per year to systematics: 20 at the Central Science Laboratories, 10 in Fisheries and Food Science and 10 in Animal Health and Veterinary Science.

Whereas the numbers of staff associated with taxonomic work in an advisory capacity have decreased in recent years, those associated with research in support of policies have been more stable.

Q7. *We still have a very incomplete knowledge of the British fauna and flora. Does MAFF see any need to change this and to target particular groups of organisms for research and funding?*

A: MAFF doubts that knowledge of the British fauna and flora could be accurately described as "very incomplete". However, it recognises that notable weaknesses do exist, for example with soil-microorganisms, immature stages of insects, mites (of which some are of economic importance), fungi and micro-plankton. MAFF is supporting scientists elucidating aspects of the systematics of those organisms relevant to its present objectives. These include, especially, microorganisms associated with the degradation of pesticides and the environmental fate of genetically modified organisms.

Q8. *Is it the intention of MAFF that the Grant in Aid to the Royal Botanic Gardens, Kew, should fund all of the research (including systematic research) carried out there, or is there an expectation that the admission charge should in part go to meeting the cost of research?*

A: The MAFF grant-in-aid is intended to provide adequate funding to enable the Board of Trustees of RBG, Kew to fulfil their obligations (including those relating to research into taxonomy and the properties of plants) under the National Heritage Act 1983. This does not preclude the Trustees from seeking funding from other sources for particular research projects; this the Trustees are doing, for example through the Kew Foundation and the Friends of Kew.

Revenue from admission charges equates with the resource costs involved in the public use and enjoyment of the Gardens.

Q9. *Much of the systematic research done at Kew is not related to agricultural crops (or to any kind of commercially exploitable plant products). Do MAFF consider it acceptable that such systematic research of a largely "pure science" nature should be competing with other calls on MAFF funding of a more applied character? Would it be more appropriate if the science carried out at Kew were funded by the DoE or a research council??*

A: MAFF's provision of grant-in-aid to RBG, Kew does not compete directly with other (ie non-statutory) calls on MAFF funding. The Department has a commitment to RBG, under the National Heritage Act 1983, to ensure that RBG's statutory responsibilities under the Act are fulfilled in the most effective and cost-efficient way.

At the time when the NHA was enacted, various options (including some linking RBG to a Government Department other than MAFF or to a research council) were considered but none was considered to be more meritorious than continuing to link the Gardens to MAFF, to which they had been attached since 1903. MAFF considers that there is still no overwhelming reason for the publicly-funded science at RBG to be funded by other than MAFF.

Q10. *Do the commercial interests involved in fruit and vegetable production and trade bear their fair share of investment in the systematic work, and the conservation of germplasm, on which scientific horticulture is so dependent?*

and

Q11. *In this connection the Vegetable Gene Bank funded by MAFF (item 2.11 of the memorandum submitted to the Sub-Committee II) is said by the AFRC (their submission 15/91, answer to Q8c), to be supported by ICI. Is this dual support satisfactory, and is the proportion contributed by the two sides appropriate?*

A: The Department acknowledges the part being played by industry in financing DUS tests for new plant varieties and by levy boards in the support of general systematic work associated with R&D projects.

MAFF considers that the extent to which scientific horticulture is dependent on the conservation of germplasm is a matter for debate. It welcomes the establishment of the Brogdale Horticultural Trust to popularise the National Fruit Collection, which will continue to be funded by MAFF.

In 1991/92, the full economic cost of the Vegetable Gene Bank is likely to be c. £160K. Of this, MAFF will provide £135K and ICI £25K. MAFF welcomes ICI's unconditional support (£60K over three years (1990/93) of the Vegetable Gene Bank and, in pursuance of its policy to seek more funds from potential users of the VGB, earnestly hopes that the ICI initiative will provide an effective catalyst.

Q12. In view of the international value of much of the work done at Kew, are MAFF satisfied that the overseas users of systematic data generated at Kew (accessed either by consultation or in its published format) are paying for this service at a realistic level? Is there scope for obtaining more support from overseas?

A: MAFF perceives RBG, Kew as a world focus of systematic botany, particularly in relation to developing countries of the sub-tropics and tropics. To maintain RBG's position, the free flow of material and specialists from overseas is important.

However, much of the research being carried out by RBG staff relates to developing countries with little resources of their own for cash support. For this reason, RBG works closely with organisations/agencies able to provide aid. In addition, the support provided for the curation of collections at RBG by visiting researchers from under-developed countries contributes effectively to the maintenance of RBG as a premier centre for botanical science.

MAFF accepts that full cross-charging by RBG through the scientific community may be counterproductive to RBG's objectives and supports RBG's present policy with regard to charging for the use of services.

Q13. Is the MAFF satisfied that the general awareness of the identity of weeds in the farming community (and perhaps at large?) is adequate for the Weeds Act requirements to be understood by those concerned? Should any steps be taken to improve public awareness of this aspect of plant systematics?

A: On the basis of its contact with farmers through the provision of advisory and consultancy services, MAFF is satisfied that the general awareness of weed identity in the farming community is adequate for the main requirements of the Weeds Act to be understood.

Q14. Similarly, is awareness of the identity of plant pests and disease symptoms at a sufficiently high level in the horticultural and agricultural communities? Does MAFF have a role in this form of systematic biology training, and is its funding adequate to perform that role?

A: The general awareness amongst farmers, growers and ancillary industries does seem reasonably good. Identifications of less common, less well-known conditions are available through ADAS Plant Clinics.

MAFF has a major responsibility in making the industry aware of new, or non-indigenous, pests and diseases and funding is available for appropriate responses to be made to individual problems.

General training in the identification of pest and disease organisms should be the remit of universities, polytechnics, colleges etc. MAFF provides specific training in-house for its staff; this training could also be made available to other organisations.

Q15. Is research of a systematic nature relating to the risks of releasing genetically manipulated organisms (GMOs) into the wild being adequately supported by the commercial bodies involved in their development, and which will presumably profit by their sale?

A: It is difficult to identify precisely what is being done with GMOs by commercial bodies. However, through new initiatives (eg the PROSAMO initiative), increasing collaboration, knowledge and understanding are being achieved between industry and the public sector. MAFF plans to expand initiatives to meet its obligations.

Q16. Have the changed priorities of the Natural History Museum in the curation of their plant collections in the herbarium affected the extent to which they can still fulfil their responsibilities under the 1969 Morton agreement (which demarcated the regional interests of RBG and NHM)?

A: MAFF is not aware that the changed priorities of the NHM have had an immediate effect on the NHM's ability to fulfil its responsibilities under the 1969 Morton agreement. However, it understands from its contacts with RBG, Kew that RBG, which coordinated many of the previously joint work programmes, has had to take an increased management responsibility and some additional research load.

Q17. University science departments are notorious for changes in policy, in staffing and in rearrangement of departmental configurations which may jeopardise the survival of "biological collections" in the broadest sense. Do MAFF believe that the move of the National Collection of Industrial and Marine Bacteria from

their control to that of Aberdeen University gives adequate long-term security to such an important systematic biological resource? Would they not accept that a university department may be a somewhat insecure home for such a collection?

A: The collection was not passed over lightly; the move of the collections was subject to an agreement between MAFF and the University to secure the future of the collection. In 1991/92, MAFF will provide £157K to the University, as part of the agreement, to secure the administration of the collection. Negotiations regarding the future of the Collection after the expiry of the present agreement at the end of 1992/93 are to commence this year.

Income from users of this Collection passes to the University.

Evidence from "Nature" Magazine

NATURE, founded in 1869 and including T H Huxley among its founding contributors, is an international journal covering all the sciences. Published weekly in London, Washington and Tokyo (as well as in Beijing with a delay of two weeks), it is well placed to monitor trends in international science. As well as the publication of original research papers, NATURE includes news and features of interest to its subscribers, now numbering in excess of 50,000. The total regular readership of the journal is estimated to be 500,000.

The status of systematic biology is of interest of NATURE and its readers for several reasons, which may be summarised as follows:

- (1) The classification of species underpins all evolutionary studies, one of the important continuing themes in science.
- (2) The long-term value even of studies concerned with a single organism, such as those in molecular biology, rests on the accurate identification of the organisms concerned.
- (3) New techniques, especially in molecular biology, offer novel approaches to the characterization and classification of organisms, but the marriage of new and old techniques requires more attention than it has been given.
- (4) The process of classification has an intellectual interest of its own, while the development of techniques for handling large amounts of data by computer technology offers the opportunity of more comprehensive coverage of natural world than has previously been possible.

What follows are the views of the editorial staff of NATURE on some (not all) of the questions raised in the committee's question-paper.

(i) What is the utility of systematic biology research?

The term "systematic biology" is used in its widest sense, encompassing all aspects of biology in which the nomenclature, classification and interrelationships of animals, plants and microorganisms are deemed to be relevant. NATURE receives relatively few papers on pure taxonomy (such research is usually more appropriately published elsewhere), but papers on all aspects of biology may include the formal specification of organisms. This may comprise Linnean binomial nomenclature, microbial strain designations, forms or subtypes.

It is important that the formal identity of any organism used as a subject for research is clearly established in formal publications, so that results gained can be confirmed or refuted later. Published research that fails to admit formal taxonomic details is thus in one sense valueless. Formal specification requires knowledge of taxonomic practice and access to reference collections, published information (such as a Flora) or the services of a taxonomist or systematist with the requisite expertise. Systematic biology, then, although clearly not at the forefront of biological research, provides an important frame of reference for the rest of biology.

Of the many research papers NATURE receives, few that concern organisms fail to specify them formally, although such omissions do occur from time to time. NATURE's latest style manual draws the attention of NATURE's editors and subeditors to the importance of formal taxonomic specification.

(iii) Is the level of UK research appropriate? If so, how does one determine appropriate volume? How does it rank with competing biological and other disciplines?

Determining the present level of research activity in systematics is difficult because of its general pervasiveness: and by what yardstick can one determine whether or not the level is "appropriate"? We think that the number of systematists who would be known as such is small relative to the number of biologists working in other areas, but using systematics. Nevertheless, the bodies of whose membership systematists form a significant part (for example the Linnean Society of London, the Systematics Association, the Geologists' Association) are active and well-established. The world-wide reaction to the changes at the Natural History Museum (outlined in the NHM's 1990-1995 Corporate Plan) would seem

to indicate that the current level of systematic research in the UK is not perceived to match the UK's traditional pre-eminence, (although this is in itself no good reason for devoting more funding to systematics).

The question of appropriateness might be considered in a more specific way, by asking whether (or not) the UK should devote effort towards the systematic investigation of particular animal or plant groups, or of the animals and plants of defined geographical areas.

For example, it is appropriate that the flora and fauna of the British Isles should be investigated by research sponsored in Britain. As a result of centuries of study (17th-Century work by the natural theologian John Ray is still cited today), the flora and fauna of Britain are among the best known in the world. But the appropriateness of British efforts overseas is more difficult.

As an initial statement, it is probably appropriate that the UK, through its Commonwealth links and the large research collections built up partly on that basis, should seek to catalyze systematic research overseas. The ODA is particularly active in this area, through its own efforts and through the Global Environmental Facility: the Natural History Museum has a strong programme of research in Belize (formerly the British Honduras), and so on. Because of Britain's traditional strengths, it is right that the UK should foster taxonomic expertise in developing countries, in particular those that contain natural habitats under threat. The NHM's collaboration with the Costa Rican Institute of Biological Diversity (INBIO) is a case in point: RBG Kew's work in north-eastern Brazil is another.

(iv) Is UK research in the right areas? Are there guiding principles which could help a "national policy" within which the existing facilities would operate eg importance in ecological/economic terms of groups of organisms; existing spread of expertise within the country; quality of resources available?

We think that there may be no need for a "national policy" governing the operation of institutions involved in systematic research. The present balance of "applied" systematics (research in government and university departments, research-council-funded institutes and so on in which systematics plays a large but not exclusive part) and "pure" systematics (museum and some university research devoted to "pure" taxonomy) seems reasonable.

Taxonomy is based on rules (such as those set out in the International Code of Zoological Nomenclature) that are constantly updated and reviewed in the light of precedent and current opinion. Working systematists use the products of taxonomy to inform day-to-day decisions (the identification of organisms according to the rules). But pure taxonomists are in closer touch with the way taxonomy itself is formulated and updated, and can advise those working systematists who seek their opinions (and who would not, in any case, have the time to devote to the elucidation of systematic relationships in particular groups.)

Resources for taxonomy in the UK are spread widely—perhaps too widely—for the viable sustenance of some small collections or research groups. Apart from the major collections held at the NHM, Kew and some universities, dozens of research collections are dotted around the country, in which the quality of curation and expertise vary widely, although there is evidence to suggest that both are deteriorating (see part v below). It would be natural that smaller collections eventually become subsumed within the larger ones, but this process requires that present owners and custodians should be given a sense that the future of their collections will be secure. Some of the criticisms levelled at the NHM's 1990–1995 corporate plan were from people fearful that collections donated to the museum in the past might be neglected in the future. Perhaps more seriously, the changes in prospect at the NHM may have deterred curators of small but important collections from depositing material there.

(v) What is the extent for our need for reference collections (type collections, living culture collections, etc) as a base for systematic research? Is provision for their storage and curation adequate? Do we have particular responsibilities to the world scientific community as a consequence of the historic circumstances of our holdings?

Reference collections of natural objects form the fundamental database for systematic research. Taxonomy could not exist were type specimens not kept in accessible museum collections, and there can be no systematics without a good range of reference material to study. Neither is it adequate for just one specimen of everything to be curated: multiplicity of specimens allows for the assessment of biological variation, which feeds back into taxonomic judgment.

Provisions for storage and curation, though, are inadequate. A recent survey (reviewed by Knell & Taylor, *Museums Journal* vol. 91: pp. 23–25, 1991) revealed that geological collections are suffering irreparable losses as a result. The same is believed to be true for natural history collections. Mould, damp, infestations, mechanical damage, mismanagement, chronic shortage of funds, low wages, understaffing and ignorance conspire to degrade collections faster than they can be adequately curated, let alone researched. The personal experience of some of us shows this to be true of museums from small local collections right up to the NHM.

Britain has a responsibility to the world scientific community inasmuch as its collections are relatively large and contain material of a scientific value that transcends national boundaries. Moreover, the utility of collections, irrespective of size, increases with the amount of study devoted to them as well as the

care with which they are curated—tiny, private collections may be far more useful than very large, public ones if there is a researcher with an active interest in the condition and documentation of the material. The only thing lacking in a small collection is the necessary access to reference material and libraries. Overall, the importance of collections in Britain is closely tied to the expertise in systematics traditionally associated with that country.

- (vi) *What new methods are there and how will this affect future UK research? Is the availability of information technology (computerised databases) to systematic research being adequately exploited? Is UK research taking cognisance of the full range of new developments in this field?*

Overview. During the past 30 years, excitement has been mounting about the prospect that detailed comparison of the molecular constitution of different species will throw a novel light on inter-species relationships. By the 1960s, the comparison of protein molecules with similar functions in different species had begun to delineate these relationships in interesting ways, but the advent of techniques for telling the structure of DNA (the universal genetic material) in the 1970s has made possible much more refined inter-species comparisons as well as studies with a direct bearing on the evolutionary history of particular species.

There is every reason to believe that the further development of these techniques will be enormously important for systematic biology. In principle, it is even possible to imagine that the collections of intact organisms that now fill museums will eventually be replaced by samples of the complete DNA from every organism (which would plainly offer great benefits in curation and conservation). But that time is still far distant. Although the cataloguing of the genetic structure of different organisms is now well under way, understanding of the functioning of an intact genome is still only rudimentary, while the relationship between the structure of a genome and the development and adult form of the organism concerned raises conceptual difficulties not yet defined. (The project to define the structure of the nematode worm *Caenorhabditis elegans*, shared between the MRC Laboratory of Molecular Biology at Cambridge and the Washington University Medical School at St Louis should throw light on those questions four of five years from now.)

Meanwhile, the need for orthodox collections of organisms, plants and animals, has been made more and not less urgent. One of the themes of this submission is that conventional systematic biology is not outdated by the development of the new techniques of molecular biology, but that the fuller understanding of evolutionary relationships between species demands a greater complementarity between the two approaches.

Examples of Current and Possible Developments:

- (1) *Gene Amplification by the Polymerase Chain Reaction*, or PCR, is a technique whereby very small quantities of DNA can be copied or “amplified” millions of times using the enzyme DNA polymerase. This enables the extraction of DNA from extremely small amounts of tissue, and even from some archaeological and fossil specimens. Genes from rare and even extinct species can now be compared: together with appropriate software support, comparative studies on genetic sequences obtained using PCR are being used to augment more traditional systematic methods. A new trend is the cross-species comparison of genes known to be involved in the regulation of developmental pathways, as well as those involved in the specification of structure. The aim of this work is to learn why species are different, rather than just the simple quantification of these differences.

The NHM is currently setting up a molecular biology laboratory to exploit the potential of its own specimens. We applaud this development but hope that the maintenance of this laboratory will not be at the expense of more traditional areas of expertise.

- (2) *Information Technology* is becoming increasingly prevalent in systematic research in the UK, although current applications concentrate more on the analysis of particular problems rather than the compilation of systematic databases. This latter task is generally seen as necessarily international, and moves are in hand at RBG Kew and elsewhere to establish databases of plant species.
- (2a) *Taxonomy and Information Technology.* Traditional methods of taxonomy by morphological description (augmented nowadays by ultrastructural and biochemical information where appropriate) will always, by virtue of their practicality and low cost, form the bedrock of taxonomy. Nevertheless, there is some virtue in the deliberate collation of this information in machine-useable form. Floras and faunas available online or in CD-ROM form could, with the appropriate funding and international regulation, form “expert systems” that could be useful adjuncts to ink-on-paper floras, faunas and keys currently in use, in that they could provide easier and more rapid cross-referencing. Professor R M May FRS has advocated the production of a “quick and dirty” listing of all known species of animal and plant as an aid to the worldwide conservation efforts now in progress. We support this concept as a basis for a worldwide standardisation of taxonomy (making it much more efficient and eliminating much duplication of effort) and as a resource upon which decisions about conservation priorities can be

made. Perhaps taxonomists can be encouraged to submit new or revised species diagnoses to computerised databases in much the same way that molecular biologists do routinely today (This would, of course, require that taxonomy can attract the same sorts of funds that molecular biology enjoys).

Looking to the future, one can imagine a time when databases contain the complete genetic sequences of a large variety of organisms (see Overview on page 5 above). Such databases would be analogous to museum collections, maintained (if not achieved) at relatively low cost. Nevertheless, the information in genetic sequences can never, by virtue of their structure, specify many of the things about species that we would find familiar, accessible or useful: such as breeding potential, ecological correlates, phenotypic variation, fossil history and so on. It will always remain as easy to discern the nature of an organism from its unadorned DNA sequence, even if complete, as it is to comprehend the message in this statement from a pile of raw paper and fluctuations in an electric current. If DNA sequence databases are to be useful at all, they will need copious supplementary information by which they can be made intelligible. As a source of supply of this information, traditional taxonomic methods will always be essential, justifying their continuing support.

- (2b) *Systematics and Information Technology.* Molecular biologists already use online databases to archive nucleotide and amino-acid sequences (databases at Los Alamos, Heidelberg and so on). NATURE encourages the submission of newly described genetic sequences to databases prior to the publication of papers concerning them. There is now a variety of relatively inexpensive software packages for computers large and small for the systematic comparison of genetic sequences as well as morphological character information. A new system currently under development by researchers at the NHM synthesizes taxonomic and ecological information to create a powerful tool whereby the "biodiversity" of various groups (according to various criteria) can be estimated. This represents a new generation of systematics software and will prove useful in assessing conservation strategies and priorities. Nevertheless, this software could not exist were neither the basic taxonomic information (collated by traditional methods) nor the theoretical support (cladistics, in the main) available.

(Cladistics is an objective method of constructing phylogenetic relationships for organisms, according to assessments of shared features derived through common evolutionary heritage. Developed by the German Entomologist W. Hennig in the 1960s, its objective formulation makes it ideal for software development. British systematists have made important contributions to the development and use of cladistic methodology.)

- (2c) *Libraries.* Taxonomy and systematics are historical sciences and depend, perhaps more than other branches of biology, on the availability of library resources. We at NATURE naturally have an economic interest in the maintenance of library resources, but are otherwise concerned that researchers are finding it increasingly difficult to gain the information they need. Financially straitened libraries are cancelling subscriptions to periodicals, and the NHM, due to staff shortages, is restricting access to its library through the institution of an appointments-only system.

We deplore these trends and suggest that the maintenance of libraries is as important to taxonomy as that of reference collections. Problems could be solved by first, increased cooperation between libraries to find ways in which burdensome inter-library loan fees could be reduced or abolished; and second, the imaginative use of computer facilities. Online literature search and retrieval facilities should be developed in parallel with taxonomic databases so that the latter are informed and made more intelligible and useful. Academic journals could publish electronic versions of themselves: indeed, this option is currently being explored by a number of journals (including NATURE and SCIENCE), and there are initiatives to market CD-ROMs containing current issues of many journals on a single disk. These initiatives are to be welcomed, but it must be emphasised that taxonomists use a great deal of old and rare literature that other biologists would not, and that attention should be devoted to identifying where these documents are held and making sure that they are maintained (even if not computerised).

- (vii) *Is the current "institutionalised" base of much of the research appropriate? Is their funding base secure? Should OAL or DES be responsible for the NHM?*

The need to maintain reference collections that include unique type specimens dictates that much research that is explicitly concerned with systematic biology is institutionalised. Even were no "in-house" researchers attendant on these collections, they should be open to study by researchers from elsewhere—an accessibility that would ensure that such collections are properly maintained. Only institutionalised collections offer the convenience of a wide range of comparative material on offer at a single location.

Institutions in which large reference collections are maintained should have secure funding. The situation at the Natural History Museum (NHM) in London raises several interesting questions. When the responsibility for funding the NHM was transferred from the DES to the OAL in 1987, NHM

researchers were able to apply to other bodies for research funds, in a similar way to researchers at universities. But the university-styled “dual support” system may not work to the benefit of museum research for two reasons.

First, it is unclear to us the extent to which the OAL regards the research commitments of the NHM as within its brief, for example the staffing and equipment of laboratories. Conversely, to what extent do research councils and government departments allow their contracted researchers at institutions like the NHM to bid for overheads?

Second, progress in taxonomy and systematics relies at its base on expertise built up over many years, in some cases over the entire working life of a scientist, with no immediate benefit accruing to that researcher, the parent institution or the funding body. It may be too much to expect that a taxonomist should seek to justify doing this kind of research at all for the purpose of completing research-council grant proposals every few years. It may therefore be inappropriate for museum research to be funded solely by a responsive-mode grant awards from research councils, government departments or industry, although these may constitute an important source of funds. Museums should be able to fund a proportion of their researchers as if they were fixed costs.

The emphasis on and type of scientific work carried out at the NHM may render the OAL inappropriate as a parent body, at least in respect of its research arm. We think that the OAL should continue to support the display and exhibitions work at the NHM, and that the ABRC should signal its support for systematic biology in the UK by taking responsibility for funding research and overheads in the five departments at the NHM in which research is undertaken (Zoology, Entomology, Palaeontology, Botany and Mineralogy) as well as the Library and the NHM’s department at Tring. It may also consider whether it could contribute to the cost of moving archived specimens from the Museum as well as the outstation at Ruislip (the lease of which is due to expire shortly) to a new depot, currently under way. In the meantime, the NHM should be encouraged to extend its own commendable efforts to raise funds through contracts from commercial clients, thus fostering an image that taxonomy has some value, rather than allowing it to be taken for granted.

(viii) If research is to be continued who pays?

(i) Should burdens of expense be shared with other countries eg an International Union of Biological Sciences (IUBS) programme? Can ESF help to rationalise activities?

Because systematic biologists may be found working in a variety of institutions, it is appropriate that funding should come from a variety of sources. It would be useful, however, for bodies to adopt—perhaps as a result of your Lordships’ deliberations—a greater degree of awareness of the (relatively modest) needs of systematists than they have hitherto. A small amount of money goes a long way in systematics, and it may be the case that systematics comes low in the scale of priorities for this very reason. It must be emphasised that (i) cheapness and value for money are not the same thing, and (ii) just because systematics is not high-profile “big science” does not mean that it is not worth pursuing.

Nevertheless, we cannot imagine that foreign sponsors will want to fund systematic research in Britain if the research facility concerned is not a “good bet”, or if it seems evident to the sponsor that the home government is in some way shirking its responsibilities. It is more likely that British researchers will go abroad to study instead. Even so, there is clearly scope for international collaborative work on particular projects, funded by appropriate international bodies. The pursuit of excellence in systematic biology is international, and ideally should be organised on an international basis (witness the international character of databases run by and for molecular biologists), but waiting for this to happen should not be an excuse for not spending funds on a national basis.

(ii) Within UK, how much should Government pay for and how best can budgets be protected?

The government should pay for such systematic research as can be accommodated as a fixed cost of running an institution for which a government agency is responsible eg long-term “pure” systematic research in museums and universities for which the benefits are not immediately apparent. Of course, any benefits that accrue could be exploited as “product” (eg in the form of consultancy), some of the profits of which should be used to fund more basic research. Budgets can be protected in the long term in part by the greater flexibility offered by financial independence (eg tax-efficient status of funds and endowments for research connected with certain learned societies, older universities and so on), but short-term funding assurance may depend on political priorities.

(ix) Is HEI teaching adequate to maintain and develop the science base?

We think that the treatment of teaching in systematic biology at the undergraduate level is inadequate. Students are confronted with the panoply of biodiversity and its attendant nomenclature without sufficient attention to underlying principles or wider relevance. We suspect that the low status accorded systematics in modern biology faculties may be partly to blame; the number of active taxonomic researchers being relatively small in British universities, the necessary courses are often taught by lecturers

not engaged in active research and who may not be familiar with the latest developments in genetics, ecology, conservation and so on in which systematics plays an important part. This situation is self-perpetuating in that students, understandably deterred from what is presented as a musty and outdated topic, turn to other fields of biology in which the importance of systematics is underplayed. In this way, systematics (like Latin) is now taught less and less well in universities and polytechnics, with the consequence that fewer and fewer systematists, of progressively lower expertise, will be charged with teaching the subject to further students as well as servicing the ever-greater demands of biology in general. Greater attention should be devoted to the teaching of systematics in higher education. If the traditional taxon-by-taxon approach is deemed outmoded, efforts should be made to integrate systematics more effectively into other branches of biology, at the same time stressing its importance as a sub-discipline that services all the others.

Notes: We acknowledge the help of the Committee in permitting access to written evidence thus far submitted for its consideration.

Supplementary Evidence from the Office of Arts and Libraries

Note by the OAL on the funding relationship between the European Commission and the National Museums and Galleries (NMGs).

1. Background

The National Museums and Galleries are, as OAL sponsored non-departmental public bodies, free to make applications to the European Commission for grants towards their various activities. All such applications are made on the discretion of the individual institution's Director and Board of Trustees.

Whilst the European Commission operates a wide range of grants towards the work of public bodies, NMGs have up to now tended to make application either under Community Framework for Research and Development or to the European Regional Development Fund.

2. Community Framework Programme for Research and Development

The Community has a Framework Programme of grants to support research work within member states. Under the Programmes' selection criteria applicants are eligible for support if their work is considered to be of sufficient scientific quality and originality and shows innovative potential. The principal form of grants is for "contracted research" and involves cost sharing between the community and applicants, where the participating institutions raise much of the finance themselves (usually half) and the community reimburses up to 50 per cent of the project costs.

3. European Regional Development Fund (ERDF)

The ERDF has existed since 1975 to help correct the main regional imbalances in the Community. Within England the regions of the North West, North East, Yorkshire and Humberside and the West Midlands are eligible for ERDF finance. Two OAL sponsored NMGs, namely the National Museums and Galleries on Merseyside and the Museum of Science and Industry in Manchester, are located within these areas as are two outstations of the Science Museum—the National Railway Museum at York and the National Museum of Photography, Film and Television at Bradford.

The Government's policy on public expenditure planning and control requires that projects generally carry PES cover. Forecasts of receipts from the Community are taken into account in setting departments' public expenditure programmes, which are, as a result, higher than they would otherwise be. Institutions are subject to their own external financing limit (EFL) or approved expenditure limit and they usually choose to finance these activities by drawing down voted Grant-in-Aid which carries its own PES cover. Once EFLs or expenditure limits are set, they are subject to the usual rules of public expenditure control. Receipt of ERDF money, which had not been taken into account in setting limits, will reduce the amount of Grant-in-Aid that an Institution may claim, although it is open to OAL to support the individual proposal for ERDF receipts and seek offsets elsewhere in its programme. The position is reviewed in successive annual Public Expenditure Surveys. The adjustment to the Grant-in-Aid may also depend upon the composition of the funding package.

A fuller exposition of the Government's policy on the operation of ERDF and attribution can be found in the minutes of evidence given by the Treasury to the Lord's Select Committee on Science and Technology (Sub Committee II) on 28 June 1990 and to the Lord's Select Committee on the European Communities (Sub Committee A) on 16 July 1991.

Evidence from Paisley College, Department of Biology

(Paper prepared by Dr A J Silverside and Dr J E Mathews, in collaboration with Prof. D J Curtis and Dr R O McLean, May 1991)

SUMMARY

Systematic Biology is seen as a subject area that remains important in modern biology. The need for continuing research is argued, noting the decline in numbers of skilled systematicists and implications in such areas as Environmental Impact Assessment and species conservation. The vital roles of national institutions, and the collections they possess, are noted, with particular reference to teaching and research at Paisley College.

RESPONSE TO DOCUMENT

Issues discussed below are numbered as in the Sub-Committee's document. Not all issues are addressed.

(i) The utility of systematics research is to update and expand our fundamental knowledge of the organisms which are part of our natural heritage. The great catalogues of species, notably those of Linnaeus, that constitute the bases of their nomenclature, were published more than two centuries ago. With ever increasing knowledge of biology at the physiological and molecular level, systematic biology has tended to become regarded as something belonging to the Victorian era. The implied assumption is that all work of value must have been completed, and that all species, save the very obscure and unimportant, must be known.

This assumption is far from the truth. The larger and more obvious groups of organisms, e.g. mammals, birds, flowering plants, are, indeed, broadly known over much of the Earth's surface, though even for these groups, the initial classification ("alpha taxonomy") is far from completed in Africa, Asia and South America. The worldwide destruction of rain forests is undoubtedly including the extinction of species that have yet to be recognised even as existing, let alone assessed for medical or other values. In the developed world, even these groups are still subject to continuing systematic research ("omega taxonomy") which refines our classificatory knowledge, gives further insights into evolutionary biology and regularly shows up important specific or infraspecific distinctions that have relevance in other biological fields.

The systematics of less conspicuous groups of organisms may be far from completely known even in the developed world. A simple example is provided by the toadstool, *Laccaria bicolor*. Although now known to be widespread in the northern hemisphere, it was not recognised as a species until 1960, significantly by a British amateur mycologist. It has now become recognised as a mycorrhizal species of particular value in afforestation programmes and is the subject of considerable research, primarily in North America. A paper published this month (May 1991), by Mueller and Gardes in the journal "*Mycological Research*", shows that work on the species has entered the "omega" taxonomic phase, with the recognition that three closely related species exist, work that is clearly important in relation to the other research supposedly carried out on "*Laccaria bicolor*".

A second toadstool example is provided by the seemingly well known Honey Fungus (*Armillaria mellea*), well known as a serious pathogen of both deciduous and coniferous trees, responsible for substantial losses in forestry and horticulture. Modern systematic research has shown that several closely related species are involved, some attacking deciduous trees, others attacking coniferous trees, while the most common taxon in northern Britain has proved to be relatively benign. In view of the physiological and ecological differences between these species, it is clear that all research on the control of the pathogens must be based on the systematics of the group.

Systematic research at Paisley College includes work on the flowering-plant genus *Euphrasia*, in Britain and north-western Europe. Specific classification in this group is still far from settled and the work includes consideration of the role of hybridisation in the evolution of taxa within the genus. Several species are British endemics, with nine species included in the British Red Data Book for Vascular Plants (Perring & Farrel, 1983) and one also on the European red data list published by the International Union for Conservation of Nature and Natural Resources. Description of an additional species endemic to north-west Scotland is forthcoming. This research is not only relevant to conservation of the species, but also suggests that infraspecific taxa may be of indicator value in the ecological assessment of ancient grasslands.

The College is active in the field of Environmental Impact Assessment (EIA), notably with regard to estuarine/marine ecosystems.

Increasingly, EIAs and studies of the biological effects of pollution require the production of evidence as to which species are affected.

This leads to a large number of people who learn to name organisms without necessarily knowing much about the relationships between different species. They regard themselves as identifiers rather than taxonomists. This is acceptable only if this body of people are backed up by experts who understand species relationships and are able to confirm identifications and recognise new or altered species.

In the field of marine invertebrate zoology, polychaete worms are commonly the dominant inhabitant in soft bottom communities and play an important rôle both as food for fish and as indicators of the effects of pollution. The standard taxonomic reference texts are Fauvel (1923 and 1927), in outmoded French, and Hartmann-Schröder (1971) in German. Considering the number of field workers, in the water industry and elsewhere, who use these texts, it is astonishing that more up to date texts have not been published. Recent taxonomic literature is widely scattered, often in unpublished form ("grey literature") and consequently difficult to obtain. While many institutions have devised their own working documents, there appears to be a lack of trained systematic biologists with sufficient expertise and funding to produce authoritative literature. The slow appearance of modern texts affects the quality of environmental impact assessments.

(ii) The limited systematic research at Paisley College is not currently limited by intellectual property rights or other regulatory provisions. It may be that one or more *Euphrasia* species (discussed above) will eventually be added to the Schedule of Protected Plants regulated by the Wildlife and Countryside Act, 1981. Provisions in the Act for collecting under licence would meet the requirements of worthwhile research.

(iii) For reasons discussed above in section (i), we feel the level of UK research is insufficient. There is a general belief that application for funding of purely taxonomic research is unlikely to be successful, though we can offer no evidence on this point. An appropriate volume of systematic research should be set at a percentage of the budget for environmental research. Systematics is a fundamental aspect of biology without which derived branches of biology cannot flourish.

(iv) National policy should be to maintain a number of systematic experts covering a broad spectrum of organisms. These individuals would then be in a position to advise on which areas are most in need of updating. We note with regret the cessation of some areas of research at the British Museum (Natural History). Learned societies exist for many groups of organisms, providing considerable expertise, but increasingly, the skilled systematicists in such societies are the gifted amateurs and professionals whose employment is in other fields. The tradition of amateur research in Britain and western Europe, while immensely valuable, is becoming increasingly inviable in the face of modern developments, as in the fields of ultrastructure and chemotaxonomy.

(v) The long history of taxonomic work in Britain has meant that many collections are of vital international importance. "Type specimens", which are the very basis of specific nomenclature, are held at many institutions, and their curation is an essential scientific requirement. Many important type collections have now been photographed and international distribution of such photographs in microfiche has been of considerable value. Nevertheless, there are limitations to the amount of information to be gained from microfiche, even where the specimens are of a nature and size to make microfiche production worthwhile. The *Euphrasia* research at Paisley College has, for example, involved examination of type material in the original Linnaean collection held by the Linnean Society of London, noting detail not visible in the available microfiche of the same collection. This work has implications for the nomenclature of the genus throughout most of Europe.

The extent of our need for reference collections cannot be accurately predicted since we do not know what future effects human activities will have on ecosystems. The Dogwhelk (*Nucella lapillus*) is common, widely distributed and of no commercial importance. However, when the rising incidence of imposex in these organisms was linked to the presence in the environment of tri-butyl-tin compounds, reference collections of this humble organism became very important. When sublethal effects are suspected, it is vital to have access to well maintained, well documented, reference collections.

In addition to national institutions, most notably the British Museum (Natural History) (now using the title, "the Natural History Museum" for many purposes), it is important that natural history sections of provincial museums are staffed by individuals with commitment and facilities for some research. They should be encouraged to liaise with schools and colleges and to provide the essential link between amateur naturalists and professional biologists. It is no longer acceptable for each educational establishment to have extensive collections of their own and local museums should therefore be a valuable shared resource. There is also a need for people involved in identification to participate in ring tests and to have their identifications verified by experts. Museum staff should be encouraged to run workshops where individuals can gain experience.

National collections that have been consulted or used by students or staff in connection with research or teaching at Paisley College in recent times include the herbaria at the Royal Botanic Gardens, Edinburgh, the Royal Botanic Gardens, Kew, the British Museum (Natural History), the Linnean Society of London and various smaller herbaria in provincial institutions. Interest has been in British, European and South American material, including consultation of types. Extensive use has been made, in the past, of the diatom collection at the British Museum (Natural History) and it is unfortunate that this is one of the areas in which the British Museum has curtailed its activities. Living culture collections have been of vital importance, regular use being made of the Cambridge Culture Collection of Algae and Protozoa, Freshwater Biological Association, Windermere and Marine Biological Association at Oban.

(vi) Current moves towards major international databases, for example in the proposed production of a new world "Species Plantarum" to cover all flowering plants are of immense importance to conservation and biology in general, and should be given full support by this country. The rôle of the

Royal Botanic Gardens, Kew, in this project, will be vital. Information technology is probably being adequately exploited in this field, though it is, again, surprising, that development of computerised identification keys is another topic curtailed by recent changes at the British Museum (Natural History).

(vii) No response.

(viii) No response.

(ix) Systematic biology forms an ever decreasing part of biology courses. It should not be allowed to disappear as a core subject. Emphasis on other aspects of modern biology, eg genetic engineering, is understandable and justifiable and can be seen as of good entrepreneurial value in relation to the biotechnology industry. Nevertheless, there is a pressing need to produce enough scientists with sufficient skills as to provide detailed and precise identifications. It should be noted that too much centralisation of systematics research would be unhelpful in maintaining systematics as a modern mainstream science.

Within our own B.Sc. Biology (Ordinary and Honours), we try to keep a balance between the understanding of biological mechanisms (relating to biotechnology) and the expression of this in terms of living organisms (relating to taxonomy and systematics), with all the levels in between (as in physiology).

(x) No response.

Supplementary Evidence from Dr Colin Patterson

What are essential differences between "care and maintenance" and full curatorial activity?

The effects of a "Care and maintenance" regime on a collection will show in several ways.

1. Accessions. They will dry up, because there will be no researcher acquiring specimens through his own efforts, or through maintaining the links with amateurs and with other professionals that result in the donation or bequest of collections. If collections do come in, there will not be the expertise necessary to identify the specimens.

2. Nomenclature of specimens and organisation of the collection. They will be fossilised at the point in time when the collection went into care and maintenance, because there will be no expert to know about changes in species-level nomenclature and in higher classification.

3. Marking up. At least in palaeontology, because no two fossils are the same, we annotate specimens that are described or figures in print, so that they can readily be found—we call this "marking-up", and it will cease in care and maintenance because of lack of the researcher's familiarity with the current literature, where specimens are cited.

4. Reprints. A specialised reprint collection is a most valuable adjunct to any collection, and in care and maintenance it will cease to grow because scientists do not send reprints to places where there is no reciprocal research output.

5. Unpublished information and understanding. This is really the museum specialist's unique contribution. Years of daily work with a collection and with visiting researchers give a museum specialist a unique background, from the perception of major unrecognised problems in systematics, to details like recognising the handwriting on labels. All this is lost when the specialist goes, and I know of no collection under full curatorial care that is not also a centre of research by the staff.

The American system of collection managers, introduced widely in the United States over the last decade or so, and now being introduced in NHM, is still too new to be properly assessed. But in North America I know good examples and bad examples. The bad examples are those where a collection manager is given so wide a spread of responsibility that he knows little or nothing about much that is in his care. The good examples would include Recent fishes at the Smithsonian, in New York and at Harvard. In each case the collection manager is a specialist with one manageable group of organisms to look after, and works in the closest cooperation with the research staff. They play their part in curation, and the collection manager publishes research papers with them, attends and gives talks at the meetings of specialist societies in the field, and so on.

C. Patterson

12 July 1991

Evidence from Portsmouth Polytechnic

(Chairman, Research Committee: Professor A. J. Pointon;
for further information contact Dr Stephen T. Moss)

INTRODUCTION

Systematic biology is of fundamental importance in all aspects of biological research; not only in the more classical disciplines at the organism level but also at the cell and molecular levels. Since the founding of systematics, there have been many attempts to classify the extraordinary diversity of life. Even though each biologist is familiar with only certain groups, many now strive to devise systematic classifications that reflect evolutionary history. Classifications not explicitly based on evolutionary relationships are termed artificial. Evolutionists agree that there is a direct relationship between time and taxa. Usually two organisms which belong to the same genus diverged more recently from their common ancestor than two organisms that belong only to the same family. The advent and understanding of molecular biology in the last thirty years has identified the commonality of the fundamental processes which underly the most essential biological phenomena; the ability to replicate and, thus to evolve. The genetic code, the rules which relate the sequence of nucleotides in RNA to the sequence of amino acids in protein, is essentially the same in all organisms. This provides evidence that all living organisms are ultimately related. *Correspondingly the biology of no organism can be understood without reference to related forms.* One aim of evolutionary studies is the construction of phylogenies that accurately represent history—phylogenies are summaries of evolutionary information. Phylogenies may be electric, using information from many sources. For example, the number of mutations which have occurred since two organisms diverged from a common ancestor may be determined from the number and types of differences between the amino-acid sequences of proteins that the organisms have in common. Nucleotide sequences of ribosomal RNAs from the same two organisms can be analysed in the same way. Computer programs can produce composite phylogenies consistent with all the protein and RNA sequences known for the organisms in question. However, in the design of these programs certain judgments and assumptions have to be made. Thus, partial phylogenies derived from macromolecular data must be compared with those based primarily on skeletal structures, external morphology of extinct and extant organisms and chromosomal cytology. Classifications based on phylogenies integrate immense quantities of information, but require revision as new information is made available. *This underlines the necessity that support for systematic research must be broad and encompass research at organism, cell and molecular levels.*

This document does not address all the issues raised by the Sub-Committee, but only those on which the author has experience and is able to offer constructive comment. Further, in order to avoid repetition the issues are not necessarily considered separately.

THE UTILITY OF SYSTEMATIC BIOLOGY

All biology is based on the ability to identify an organism and recognize its relationship with others. An understanding of the ontogeny of structures is aided by, and indeed reflects, knowledge of its phylogeny. Systematic biology and the deposition of authenticated (validated) material in culture collections are of paramount importance to the scientific community for many reasons, including:

1. the supply of authentic material to research workers;
2. newly described species require to be compared with morphologically and cytologically similar specimens and then deposited in a culture collection(s) for future reference;
3. knowledge of an organism's relationship with other species aids in the breeding of new strains, either by gene transfer or crossing with strains which possess the required character(s);
4. the selection of micro-organisms to screen for useful secondary metabolites is considerably enhanced by knowledge of their taxonomic affinities;
5. biostratigraphy is heavily dependent upon systematic studies of fossil groups with arguably complete fossil records, and is a major tool for well site correlation in the oil industry.

Without the information obtained from systematic biology ordered research would be impossible. Unfortunately, many research workers accept the identified organisms on which they work with little comprehension of, or consideration for, the large amount of systematic research required to confirm their taxonomic status.

REFERENCE COLLECTIONS

The significance and usefulness of systematic research are determined not just by the quality of the research but more essentially by the ability to cross reference that research to an identified individual or individuals. That individual(s) being representative of a clone(s). Subsequent systematic research may depend on access to these clones and thus their availability for comparative studies relies on access to reference collections. If these collections remain the domain of the individual research worker, group of

research workers, or even independently-funded research units, they may be as ephemeral as that person(s) or unit. The recent loss of the marine fungal culture collection at the Institut für Meeresforschung, West Germany, is just one example of the susceptibility of these collections to changes in staff and "local" policy. Reference collections should be comprehensive and supported directly from government funds.

Owing to the global nature of systematic research, availability to all type material should be maintained. It is unlikely, and perhaps not desirable, that all types from all taxa should be maintained within a single collection. International cooperation at governmental level is required in order that there can be a worldwide policy on the maintenance of culture and reference collections. This may allow the retention of all type specimens and make them readily available to all workers. International collaboration is presently facilitated by meetings of the World Federation of Culture Collections under the auspices of the International Union of Biological Sciences, funded by a subvention from UNESCO and dues paid by countries adhering to the International Council of Scientific Unions. Many specialist culture collections (eg the marine fungal collection at Portsmouth Polytechnic) which contain types and strains are maintained by individuals on funds generated from research grants or contracts with industry. This type of funding is unpredictable and the future maintenance of these usually unique collections is uncertain. Financial support for these recognised specialists collections is of paramount importance in any overall national and/or international strategy for the funding of culture collections.

There exist culture/reference collections of living material (eg International Mycological Institute) which are predominantly for microbiological types, zoological (eg Zoological Society of London, Regents Park) and botanical (eg Royal Botanic Garden, Kew) gardens for macrobiological types and there are collections of "preserved" non-living material (eg British Museum of Natural History). These collections and many others constitute an invaluable and irreplaceable world collection of types. Britain has a unique collection of material in its many National, International, Industrial, University/Polytechnic culture collections and museums and it is of fundamental importance that these be maintained. The decline in funding to these collections in recent years has put at jeopardy types which the World cannot afford to lose. Support for culture collections should be increased in order to accommodate the information derived from the more recent aspects of systematic research—electron microscopy, serology, immunology, molecular biology. For example, a reference collection of strains that have cloned DNA probes.

FINANCIAL SUPPORT FOR SYSTEMATIC RESEARCH

It is not a question of "if research is to be continued" but where should the support for this fundamental research be derived. For the reasons stated elsewhere in this document, systematic research must be continued. Competitive research grants provide only limited support. Seldom do they provide sufficient funds for long term studies and yet it is the continuing studies that allow expertise to be developed and a large number of specimens examined. Systematic research depends upon comparative study, the more organisms studied the more significant the phylogenies derived. Similarly, the greater the aspects of any organism studied the more accurate are the phylogenies. Correspondingly, in addition to the support for culture/reference collections there is a requirement for permanent funding for systematic research which is independent of the current research funding authorities (eg NERC, SERC), or a sum allocated to these authorities specifically for systematic research. An initiative for systematic research is required at the National level. However, systematic research is of International importance and cooperation between countries is desirable in order that research programmes can be rationalised and coordinated. Adequate baseline funding to support multidisciplinary groups is best if provided by, and considered the responsibility of, individual governments, with an Internationally supported fund for more speculative research and large multinational initiatives.

However desirable it would be for industry to provide support for systematic research this situation is unlikely to be realised. Industry maintains culture collections solely for commercial exploitation (eg useful secondary metabolites) and not generally for the elucidation of phylogenies. Funding from industry can only be obtained if the commercial application justifies the expenditure. Thus the logical source of funding from industry is in the fees for services and cultures provided by collections.

The level of funding for systematic research in the UK cannot be considered adequate. The number of grants awarded annually for pure taxonomic biology is not high. It is difficult to identify specific ecological, physiological or taxonomic assemblages of organisms that require special attention. The taxonomy of nearly all are poorly understood, particularly at the molecular level. However, the marine lower organisms—protists, fungi, protozoa and algae—have received much less attention than their terrestrial and freshwater counterparts and are in urgent need of investigation. Particularly with the importance of these organisms as indicators of global environmental changes.

INFORMATION TECHNOLOGY AND NEW METHODS

Many new methods have been developed in recent years and as these become routine tools in taxonomic studies it will be necessary to ensure that there is sufficient funding in Universities and Polytechnics for them to be adopted. These methods include DNA sequencing, nucleic hybridization and immunological work. The greater the number of techniques utilized and the number of specimens

described so the more difficult it is to access information. Information technology is being used extensively in microbiology and a number of comprehensive data bases are in use. These include the MiCIS (Microbial Culture Information Service), the MSDN (Microbial Strain Data Network) and the MINE (Microbial Information Network Europe) data bases. What is required is access to these data bases by all laboratories working on systematic biology and continued financial support to these centres by the governments of participating countries.

TEACHING OF SYSTEMATIC BIOLOGY

There is no doubt that, in general, the present level of systematic biology teaching in British Universities and Polytechnics is totally inadequate. If this situation is not corrected, the "nucleus" of persons qualified in systematic biology and its associated techniques will not support the future needs of biological research. Present degree courses demote the teaching of systematic biology to the minimum considered necessary to enable students to distinguish major phyla. This teaching tends to concentrate on the ability to recognize members of phyla rather than to understand the principles on which their taxonomy is based.

SUMMARY

The reader may deduce from this document that the author is a microbiologist with a major research interest in fungal taxonomy. Pivotal to our studies at Portsmouth Polytechnic is access to a culture collection of marine fungi. The most comprehensive and largest international collection of marine fungi is held at the Polytechnic. The maintenance of the collection is dependent on monies raised by the sale of cultures to industry. This is a limited resource and does not allow funds for computerisation of the collection records or experimentation with new methods of preservation (eg, cryogenics). Further, the maintenance of this invaluable collection depends upon the interests of the present staff. This collection is not unique in its funding problems but only reflects the situation of many laboratories. A national or international initiative is required to identify all culture collections and to review their funding.

The second aspect of concern is the funding for future research and the availability of graduates with a good knowledge of systematic biology to fill research positions. in the U.K. both these aspects are below the acceptable level.

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Evidence from the Public Health Laboratory Service

Evidence submitted below is given in the context of human and animal infectious pathogenic microorganisms and in relation to the role of the Public Health Laboratory Service (PHLS). The Summary objective of the PHLS (Corporate Plan, 1990, p.2; see also p.5) is: "... prevention and control of human infectious diseases in England and Wales, through provision of laboratory and epidemiological services and associated research...", which entails, principally, diagnostic microbiology, national surveillance, investigation of outbreaks, and research and development.

The PHLS operates a network of laboratories coordinated from its centre at Colindale, North London. There are 52 area and regional laboratories throughout England and Wales, the Centre for Applied Microbiology and Research (CAMR) at Porton Down, the Central Public Health Laboratory (CPHL) and the Communicable Disease Surveillance Centre (CDSC) in North London. In carrying out their functions, PHLS laboratories depend greatly on the ability to identify microbes precisely and to perform detailed typing within species.

The PHLS maintains Reference Laboratories, most of which are at CPHL but several are located in area and regional laboratories. PHLS Reference Laboratories provide expertise and services in specified fields of microbiology, including identification, typing and sub-typing of pathogens. Associated research and development may involve systematics research and the development of typing and sub-typing methods for "new" and "emerging" pathogens. One of the PHLS Reference Laboratories is the National Collection of Type Cultures (NCTC) in which systematics research is undertaken that complements and may extend that of the other Reference Laboratories.

The PHLS also manages two other important collections; the National Collection of Pathogenic Fungi (NCPF), and the European Collection of Animal Cell Cultures (ECACC).

(i) *Utility of Systematic Research.* It is difficult in PHLS work to identify a borderline between surveillance, outbreak investigations and surveys, on the one hand, and research and development on the other. Diagnostic microbiology, national surveillance and outbreak investigations are highly dependent upon accurate, reliable identification of microorganisms, isolated from patients and clinical or other environments. Accuracy of identification is dependent, in turn, on systematic biology research. Patterns of infectious diseases, due to well-established pathogens or to new or emerging agents, are

continuously changing. Infectious disease surveillance data for England and Wales is reported weekly in the PHLS Communicable Diseases Report and depends heavily on the ability to specify causative organisms systematically. Continued research to ensure that identification procedures meet the requirements dictated by changing epidemiology is therefore vital to public health. "Identification" is taken here to include also the recognition of different races, or types, within species: commonly called "typing". The importance of precise identification and typing may be illustrated by the following examples.

Diagnosis of Salmonella food poisoning requires identification of the causative microorganism only to genus level, but the investigation of outbreaks to determine the source of the infection requires more detailed identification and typing. The present classification of salmonellas includes only one species comprising seven subspecies; just one of these causes almost all human salmonella infections. This subspecies can be divided into almost 2000 serovars but, in 1991, over 80 per cent of all human infections reported in England and Wales were due to only two serovars, *S. enteritidis* and *S. typhimurium*. To trace the source of outbreaks further discrimination is required and methods that depend on the specificity of bacteriophages have been developed ("phage typing"): up to 200 phage types can be distinguished within a single serovar. However, in 1991, over 85 per cent of all infections due to *S. enteritidis* were due to a single type, *S. enteritidis* PT4. Continued research is required to develop methods for the yet further discrimination of these bacteria; these methods are likely to depend on molecular biology. Since the prevalence of the individual serovars changes with time (altering their public health importance), it is necessary to continually develop new typing methods or to expand existing methods to discriminate further among the most common serovars and phage types.

New and emerging pathogens present a similar problem. The causative organism of Legionnaires' Disease, *Legionella pneumophila*, has been extensively studied in recent years. Thirty-four other species of legionella have been described and at least 14 serogroups of *L. pneumophila* have been distinguished. Since strains of legionella, including those responsible for human disease, are ubiquitous and can be found in the water systems of more than half of all buildings studied, precise typing methods are essential for the investigation of outbreaks of disease. Only by epidemiological studies using such typing methods is it possible to pinpoint the source of the infecting organism and to take intervention methods to terminate the outbreak. Further research is required to improve the speed and discrimination of the identification and typing methods and, once again, these methods are likely to depend on molecular biology.

Systematic biology also provides the basis for comparison of interactions between organisms in natural, semi-natural and man-made environments. Without clear understanding of what groupings of organisms exist in a given environment it is impossible to reach well-founded conclusions on how they interact. This is as true for host-pathogen relationships and industrial processes as it is for natural ecosystems. Of current, and growing, concern are questions regarding the release of genetically modified organisms (GMOs) into the environment: accurate identification-typing of these is essential in order to trace them and to distinguish them from naturally occurring organisms, many of which are poorly studied.

The application of "systematics" to animal cells is perhaps stretching a point because unlike other microorganisms there is no taxonomic structure for the cells in isolation from the animal of origin. There is therefore a definite need to develop new techniques in order to identify cell lines more readily without reference back to the Linnaean system.

Systematic research is therefore fundamental and is open-ended in that our knowledge of microorganisms is never complete: as new technologies emerge, new knowledge is added.

(ii) *Need to specify particular organisms.* As outlined above, specification is of vital importance in the work of the PHLS. In addition, at regulatory levels we are affected by the guidelines and regulations of the Advisory Committee on Dangerous Pathogens (ACDP) and the Health and Safety Executive (HSE), which rely on systematic knowledge to categorise species to different Hazard Groups which, in turn, impinge on Codes of Practice, laboratory containment facilities, training, adherence (in letter and spirit) to National and International regulations concerning exchange of cultures between laboratories, and issuance of Hazard Notices consequent to the Control of Substances Hazardous to Health (COSHH) legislation.

With regard to Patents, the PHLS manages two Collections which are International Depository Authorities (NCTC and ECACC) and whilst the Budapest Treaty does not make it mandatory for Patent authors to specify useful organisms by species names, some systematic knowledge has to be revealed, if only to establish that the patentable organisms are of a kind within the competence of the Collections concerned.

For animal cell lines, accurate characterisation and identification of the living resources held in ECACC is needed because of the limitations of traditional methods. Added research in this field would result in improved identification of potentially valuable cells with unique properties and also could speed up the process by which regulatory approval is given to therapeutic products derived from animal cells presently held back because of safety considerations.

Specification of particular organisms is therefore necessary for both the basic functions of PHLS and also to meet statutory regulations.

(iii) *Level of UK research.* Qualitatively the level of UK research is of the highest calibre, but the volume carried out appears to be declining. For pathogenic microorganisms, the principal practitioners are in Medical Schools, Universities, PHLS, and some other government-funded bodies. Contacts with non-PHLS units suggest ever increasing reliance on “soft” money, and within the PHLS, the routine service demands continually increase, leaving reduced leeway for research. Increasingly, research can be justified only on the topics of highest priority in relation to the infection control functions of the PHLS. At the same time, words such as Taxonomy, Systematics, etc, no longer appear in MRC annual listings of Project Grants. The PHLS would welcome an increase in funding for systematic research.

(iv) *Is UK research in the right areas?* It would be helpful if bodies that fund research should publish their research strategies giving a clear indication of policies and priorities. Within the field of health care the strategies of public bodies need to be consistent with the overall priorities determined by the Department of Health.

Within the PHLS the priorities for research are summarised in the Corporate Plan produced annually by the PHLS Board. These priorities are in turn developed on the basis of more detailed analyses contained in the proposed biennial PHLS publication “Infections and Communicable Diseases in England and Wales”.

In general, PHLS research is directed towards particular pathogenic microorganisms. The priority given to individual organisms is assessed on the basis of the following guidelines:

- how common are the infections
- how severe are the infections
- is the incidence of infections increasing
- is research likely to lead to successful measures for the diagnosis, treatment or control of infection
- is the PHLS well-equipped in terms of expertise and resources to carry out the research

Once an organism has been recognised as a priority area for PHLS research the development or improvement of methods for the detection, isolation, identification and typing of the organism becomes an essential prerequisite for epidemiological studies and control of infection. These developments and improvements clearly require *systematic* microbiology research.

The PHLS currently recognises the following organisms as priority areas:

Human immunodeficiency virus (HIV)

AIDS is the most important single infection at the present time. The disease is severe and may be universally fatal. Available treatments are of limited success. Surveillance is vital and depends on continued research to develop improved methods of diagnosis.

Salmonella

In 1990 over 30,000 cases of salmonella infection were confirmed by the isolation and identification of the organism. In recent years there has been a large increase in infections due to *S. enteritidis* associated with poultry and eggs. Development and application of control measures has a high priority and depends on the continued development of rapid and highly discriminatory isolation, identification and typing methods.

Campylobacter jejuni

The incidence of infections due to this organism is high (about 30,000 cases per year) and appears to be rising. Infections are usually sporadic and are generally not severe. The promotion of kitchen hygiene and research directed at the prevention of infection in poultry are priority areas.

Legionella pneumophila

Although only 200-300 cases of Legionnaires’ disease are known to occur in England and Wales each year, this organism is considered a priority because outbreaks of serious infection occur and are associated with contaminated water in air cooling systems. Infections can therefore be prevented by surveillance and the prevention of contamination in water systems. Surveillance requires the continued development of rapid, discriminatory methods of isolation, identification and typing.

Cryptosporidium

Large outbreaks of cryptosporidiosis occur associated with contaminated drinking water supplies. There is no effective treatment and the symptoms are more prolonged than most other intestinal infections. In order to ensure that the Agent is removed by water purification systems rapid, sensitive and specific methods of detection are essential and their development depends on an understanding of the systematic microbiology of the organism.

Neisseria meningitidis

Infectious meningitis and septicaemia due to these organisms occur predominantly in young children and have a high mortality. A vaccine is available for Group A strains but not for Group B which is the more important cause of disease in England and Wales. Vaccine development depends on systematic microbiology research.

Haemophilus influenzae

This organism is important because it causes severe disease, particularly bacteraemia, meningitis and epiglottitis, especially in young children. Vaccines are currently being assessed and their development has been based on systematic research.

Verocytotoxin-producing Escherichia coli 0157 (VTEC 0157)

E. coli 0157 infections are a cause for concern because they are increasing in number and the clinical conditions that they cause may be severe, including haemorrhagic colitis and the haemolytic uraemic syndrome (HUS). HUS due to *E. coli* 0157 is probably the most important single cause of acute renal failure in children in the UK. In North America outbreaks are associated with undercooked minced beef and with unpasteurised milk. The sources of infection in the UK are not known. There is an urgent need for the development of improved methods of detection of the organism in foods, milk and clinical specimens. This development depends on a good understanding of the systematic microbiology of the organism.

Influenza viruses

Influenza is an important disease because large outbreaks may occur and there may be significant morbidity and mortality. Currently available vaccines are only partially effective and their development is complicated by the genetic and antigenic variability of the viruses. Development of improved vaccines requires a good understanding of the systematic microbiology of the viruses.

Listeria monocytogenes

This ubiquitous environmental bacillus causes an uncommon but serious illness, particularly in neonates and the immunosuppressed. Mild maternal infection in pregnancy can lead to foetal infection and stillbirth. During the late 1980s the disease increased in incidence and became a cause for concern. The development of accurate identification and serotyping methods by the PHLS made it possible to identify a particular food source. Health warnings were issued and measures were taken to eliminate the contamination. The number of infections has now declined dramatically.

In conclusion, UK research is broadly in the right areas, as the PHLS has in-depth study groups (Reference Laboratories) for major pathogens and R&D is directed towards the needs of the Service, often by the activities of collaborative working parties. However, there are many species additional to those mentioned above which, separately, are not important enough to justify the establishment of further Reference Laboratories yet, collectively, have a significant cost to the national economy (lost working days, hospitalisation, medicines, etc). For the PHLS, these miscellanea are in part covered by two of the National Collections (NCTC and NCPF).

(v) *Culture Collections.* The need for authenticated cultures is self-evident, for properly conserved cultures provide the links between succeeding generations of workers. Inclusion of material from other countries is essential, as microorganisms do not recognise national boundaries and, of course, international travel increases. The value of a collection depends upon the comprehensiveness of cultures stocked, technical standards, and expertise of collection staff. The UK network of some 10 semi-specialised service National collections (see Appendix) is scientifically superior to the USA system which, essentially, embraces all subdisciplines into one monolithic centre (the American Type Culture Collection, ATCC).

For pathogenic bacteria, the UK is serviced by the National Collection of Type Cultures, a unit of the PHLS: NCTC can, and does, call on the wider expertise of the rest of the PHLS.

In medical mycology the NCPF holds pathogenic fungi for supply to scientists and researchers. NCPF also has some herbarium material and a good library of specialist literature. However, the range of pathogens recognised in immunocompromised patients is increasing and includes some fungi of primarily saprophytic or plant pathogenic origins.

A deficiency of the UK system is that each collection has a limit to its remit, making it difficult to expand into new areas. In recent years, at least two significant gaps in the UK network have been identified: service collections for Cell Lines, and for Viruses.

The Cell Line gap has been remedied: the European Collection of Animal Cell Cultures, ECACC, has been established within the PHLS at CMAR. ECACC was set up in 1984 to provide an effective European alternative to the ATCC for patent deposits and provision of cell lines especially for the biotechnology industry. ECACC is now also a resource supporting epidemiological studies on inherited disorders and

makes a unique contribution to the Human Genome Mapping project funded by the MRC. This service is not performed in isolation, however, and reference banks of cell lines for several purposes are being created at ECACC under the auspices of the World Health Organisation and the European Society for Animal Cell Technology. In addition, there is an exchange scheme for cell lines with the Riken Gene Bank in Japan. Some of these cell banks are of economic importance in that they will benefit third world countries in particular who need access to this type of well-characterised material for production of biologicals.

However, there is still no UK national collection for Viruses.

Overall then, provision for storage and curation of biotic material in the UK is good but not fully adequate. Volume of systematic research carried out in National collections varies from little or none (National Collections of Industrial and Marine Bacteria Ltd) to considerable (NCTC above-mentioned; however largely dependent upon "soft" money). The UK does have responsibilities to the world community; UK collections were amongst the first to be established (NCTC, 1920) and many cultures were voluntarily donated from abroad. Regrettably, the use of UK collections by overseas clients has declined. A particular problem is that fees for services (especially selling prices of cultures) are geared to levels appropriate for our home economy, often beyond the means of developing countries.

(vi) *New Methods* continually emerge, principally now at the molecular level. Such methods generally involve molecular biology including the application of DNA technology, protein analysis, polysaccharide analysis, or immunological techniques, although whole cell analysis methods such as pyrolysis mass spectrometry are also under investigation. Newer techniques tend to be more costly, especially when in experimental-developmental phases, and particularly so when such methods at least initially have to be test-proven in parallel with old, well-established methods. ("Initially" in this context can mean a few years.)

With the increasing use of DNA, protein and polysaccharide analysis in microbial identification and typing the need for widely available, computerised databases becomes more pressing. A number of commercial databases exist for DNA and protein sequences and for restriction enzyme sites. However, such databases are not available for plasmid typing or for genomic "fingerprinting" and scientists depend on databases developed in-house. There would be great advantage in the development and standardisation of these databases. Wider use of these and of existing commercial databases would improve the availability of standard gene probes, for example, and would encourage the wider use of methods that are at present restricted to a few specialised laboratories. Methods of electrophoretic analysis of structural proteins, enzymes or polysaccharides can be sufficiently reproducible to permit the development of useful computer databases, but at present such development is slow due to the scale of accurate work, with appropriate internal and external controls, that needs to be done.

The UK has actively contributed data to computerised databases for culture collection resources and much data is now available on-line via databases of the Microbial Culture Information Service (MiCIS), Microbial Information Network Europe (MINE), Information Centre for European Culture Collections (IC-ECC), Microbial Strain Data Network (MSDN), and the World Data Centre (WDC). An existing problem with such databases, for UK Collections, is that of keeping them up-dated. The volume of information technology work has grown, in large collections at least, to a level that requires a full-time Information Scientist. It is probable that systematic information whilst being exploited could be yet more utilised.

(vii) *"Institutionalised" base.* Research and development is an important component of the role of the PHLS and has been supported, as far as possible, by central funding from the regular budget. Additional research funds have been gained in competition with others from the usual grant awarding bodies, including Department of Health (DoH), Medical Research Council (MRC), World Health Organisation (WHO) and the Wellcome Foundation, Ministry of Agriculture Fisheries and Food (MAFF), the Commission of the European Communities (CEC). In common with other research organisations, the PHLS would welcome additional research funding.

With the implementation of the NHS and Community Care Act 1990 the arrangements for PHLS funding will change. Diagnostic microbiology undertaken by PHLS area and regional laboratories for health districts and others will no longer be centrally funded by DoH and it will be necessary for the PHLS to recover the costs for these services from the purchasers with whom the PHLS contracts. The PHLS understands that the essential national and community work of the PHLS will continue to be funded by DoH and the Welsh Office including its central reference services. Nevertheless, a period of change is beginning and there will inevitably be concern about the level and security of research funding, both in the Reference Laboratories and in PHLS area and regional laboratories.

The funding of Systematic Biology Research in Universities depends upon individual interests and research groups could lose their connection with the subject at short notice. The PHLS has the intention of maintaining systematics research activities relevant to its objectives in the control of infectious disease, primarily through the work of NCTC, NCPF, ECACC and the Reference and the Reference Laboratories.

The major role of ECACC (to provide cultures of cell lines, patent and other deposit facilities and contract services for characterisation of cell lines) is funded by the income received. Because of the nature of the resource there are opportunities to contribute to basic science, but within the present

structure and constraints on charging, basic research cannot be funded from income. It is necessary to attract research grant support which could be used very cost effectively in view of the resources already in place. The major problem is simply shortage of funding for basic research such that even alpha-rated projects go unfunded. At present there is no international coordinated approach to funding of research of this nature. Although industry has an interest in the results of this work they are by no means in the best position to carry it out; for example, they do not hold such an extensive range of cell lines.

(viii) *Who pays?*

- (i) The main funding of Systematic Biology research rests with the UK government but international collaborations, with shared expenses occurs and should be further encouraged. UN agencies can probably help only marginally, as the funds available to, eg UNESCO (from which USA and UK have withdrawn membership), or WHO, FAO, are generally limited and, understandably, developing countries have preferential treatment. The Commission of the European Communities is a better prospect; agencies such as the European Science Foundation need exploring. Scientific agencies such as the European Culture Collection Organisation could assist coordination, but has no funds of its own.

Culture Collections have many informal international links, arising from the very nature of their supply functions: further funding to the Collections specifically directed to systematic R&D, would give relatively quick results.

- (ii) Although it may not be acceptable to protect budgets for systematic R&D, it is important that bodies funding research recognise its value to wide areas of science. Assessment of research proposals in applied systematics may be helped by establishing criteria, such as work that demonstrably shows improved accuracy, or detail, or speed of execution, automation, ease of use, wider coverage of microorganisms.
- (iii) Industry: probably more interested in the end-product of systematic research, rather than the research itself. Molecular technologies are leading to identification and typing kits, general and specific probes, etc. Food industry help ought to be sought to cost-share the basic research.

(ix) *Adequacy of teaching.* Apart from training its own staff the formal teaching role of the PHLS is restricted to the provision of training in epidemiology for Community Communicable Disease Consultants (CCDCs) and others on behalf of DoH. Nevertheless, many members of the PHLS staff participate as teachers on postgraduate courses organised by other bodies. These courses include those leading to MSc (Medical Microbiology) and may include a systematic microbiology component. In addition, NCTC, NCPF and ECACC are involved on an ad hoc basis with both WHO and UNESCO in training. There is an important role for such resource centres in the provision of expertise to new centres to assist them in the introduction of appropriate technology. For example, India has recently made a substantial investment in a new animal cell culture collection. PHLS therefore contributes indirectly to teaching in this field for the benefit of the scientific community in general.

In providing appropriate training for its own staff, PHLS is concerned that the systematics component of existing degree courses in microbiology, both at first degree level and at MSc level, has been greatly reduced in recent years. This is particularly noticeable in medical mycology where it has become necessary to recruit from workers in general mycology in order to find personnel with training that includes details of fungal life histories.

(x) *To learn from Abroad.* In some centres overseas the research role is dominant and the service function is secondary. These are rather extreme cases but it is important to emphasise that the value of the cultures and cell lines held in collections is dependent upon data derived from research. In the USA funding is made available for this type of research mainly by NIH and, for example, has enabled ATCC to develop "Certified Cell Line" status for some of the deposits thus benefiting the users enormously. This approach would substantially benefit similar UK centres and improve the value of the service provided.

General Conclusions. Much systematic research work needs to be done, even for pathogenic microorganisms which are relatively well-studied. A substantial move into molecular identification-typing methods, which are fundamentally more informative than existing methods, is hampered by current financial constraints. In previous decades, the UK was a lead country but that position is steadily being eroded. The UK is well-endowed with culture collections of high standards (though, as noted, gaps in available resources still persist); it is probable that these resource collections are not being exploited to the extent that they could as centres for systematic research. At the same time, service collections are in ideal positions to collaborate, nationally and internationally, with other units carrying out systematic research.

APPENDIX

National Collection of Type Cultures

(Pathogenic bacteria of Medical and Veterinary importance, plasmids)

Central Public Health Laboratory
61 Colindale Avenue
London NW9 5HT

National Collection of Pathogenic Fungi

(Pathogenic fungi and yeasts)

Central Public Health Laboratory
61 Colindale Avenue
London NW9 5HT

Culture Collections of Algae and Protozoa

(Freshwater algae and protozoa)

The Ferry House
Ambleside
Cumbria LA22 0LP

(Marine algae)

Scottish Marine Biological Association
Dunstaffnage Marine Research Laboratory
PO Box 3
Oban
Argyll PA34 4AD

European Collection of Animal Cell Cultures

(Animal Cell Lines)

PHLS Centre for Applied Microbiology and Research
Porton Down
Salisbury
Wiltshire SP4 0JG

National Collections of Industrial and Marine Bacteria Ltd

(Bacteria of Industrial and of Marine Importance)

23 St Machar Drive
Aberdeen AB2 1RY

National Collection of Food Bacteria

(Bacteria from milk, milk products and food)

AFRC Institute of Food Research
Shinfield
Nr Reading
Berks

National Collection of Plant Pathogenic Bacteria

(Bacteria pathogenic to plants)

Plant Pathology Laboratory
Hatching Green
Harpenden
Herts AL5 2BD

CAB International Mycological Institute

(Fungi other than animal pathogens and wood-rotting fungi)

Ferry Lane
Kew
Surrey TW9 3AF

National Collection of Wood-rotting Macrofungi

(Wood-rotting fungi)

Building Research Establishment
Bucknall Lane
Watford
Herts WD2 7JR

National Collection of Yeast Cultures

(Yeasts other than pathogens)

AFRC Institute of Food Research
Colney Lane
Norwich NR4 7UA

Evidence from the Rare Breeds Survival Trust

Thank you for your letter of 29 April on the Select Committee on Science and Technology Sub-Committee II—Systematic Biology Research.

The RBST is not greatly concerned with problems at the species level. It is, however, greatly involved in genetic problems at the sub-species level. The species that comprise domesticated animals are well-defined but breeds that are in many ways similar to wild sub-species are not well-defined objectively. We have no way of knowing how breeds may be objectively defined apart from "breed standards" that simply reflect the superficial characters of appearance. And yet the ancient lineages of many breeds are well authenticated and constitute a store of genetic diversity encompassing the full heterogeneity of the species.

It is important that breeds should be characterised by as many genetic variables as possible including breed types, DNA structure and other cellular features. Research in this area has never progressed far in the UK. Attempts have been made, mainly at Government research institutes, to define breed types in cattle and sheep but this work has never been completed due, presumably, to lack of funding. The RBST is keen to co-operate in promoting this kind of research, and new research on DNA, and would wish to collaborate with the Natural History Museum, the Institute of Zoology and other interested parties. We think it is greatly in the interest of the British livestock industry to be in possession of full data about all our breeds and in the country's interest for Government funding to be made available for further research into breeds of livestock.

Lawrence Alderson

Executive Director

Evidence from Dr Peter Raven, Missouri Botanical Garden

I am pleased to send some comments in relation to your inquiry on behalf of Sub-Committee II of the House of Lords on systematic biology research.

I shall now attempt to provide some testimony in relation to your questions.

Outlining briefly the state of biodiversity and its applicability to human affairs, I submit the following.

There are approximately 1.4 million described species of organisms—plants, animals, fungi, and microorganisms. Until about ten years ago, a responsible estimate of the actual total number of species in the world would have been three to four million species, perhaps two to three times the number of those that had actually been described and classified. Following further investigations of insects in the tropics, however, these estimates have had to be revised upward, and now a conservative estimate of the overall level of biodiversity of the number of species of organisms in the world might be ten million, although it could be much higher than that.

At any rate, we obviously have named and classified only a very small proportion of the existing species—fifteen per cent or fewer. For some groups of organisms—plants (which I define as including only vascular plants and bryophytes and which thus number fewer than 300,000 species), vertebrate animals, butterflies, and some other groups of insects—we have a reasonable idea of how many species exist and a relatively good level of knowledge about the classification and characteristics of the species worldwide. For most other groups, we know very little. For example, scientists often estimate that there may be as many as a million or more species of nematodes (roundworms), but only 13,000 have actually been named and described to date, and there are fewer than a dozen specialists worldwide dealing with the classification of species other than those that are parasitic on plants or animals. Thus, no serious effort is even being made to estimate worldwide levels of biodiversity much less to deal with them adequately.

Biodiversity, not surprisingly, is distributed unequally around the world. Of the 1.4 million named and classified species of organisms, I estimate that about one million live in temperate regions and about 400,000 in tropical regions. Two hundred thousand of the latter group are plants and vertebrates, leaving approximately 200,000 named species or organisms other than plants or vertebrates for the tropics of the entire world, including Latin America, Africa, and tropical Asia. A really conservative estimate of the actual numbers of species of organisms in these groups in these areas would be at least eight million species, so it can be seen that we really know next to nothing and that our ability to understand the patterns of distribution or the relevance of these organisms to the proper functioning of communities is very limited indeed.

Concerning the relevance of organisms to human affairs, there can be no doubt that 80 per cent of the calories consumed by human beings depend directly or indirectly on only 20 species of plants, and three of these—wheat, rice, and maize—supply nearly two-thirds of the total. Tens of thousands of

additional species of plants have been estimated to afford potential sources of food, and most of these occur in tropical regions where the need is most serious. Despite these obvious relationships, little or no effort is being made to develop additional sources of food.

On another front, plants are the major source of medicines worldwide, with some three-quarters of the people in the world depending directly upon them for their needs, and yet we have investigated very few of the total number available for these purposes. Adding a few other points, such as the fact that more than 3,000 kinds of antibiotics have been patented since World War II, even in the absence of any sort of concerted systematic search for such medicines, one is left with a clear impression that a proper understanding of the diversity of organisms has much to offer us and that we have not really yet begun to exploit it properly, especially in terms of the needs of a modern industrial society.

Considering that all 20 of the major plants mentioned above have been in cultivation for at least 2,000 years and that our needs today are vastly different from what they were then, it becomes clear that we have really not begun the process of exploration and understanding that is necessary to utilise biodiversity properly.

Organisms individually are our only source, ultimately, of sustainable productivity. From them we can derive all sorts of products that we use to feed, cure, clothe, and shelter ourselves. Organisms collectively make up the world's biological communities, rich in species in the tropics, poor in temperate regions. Those communities function well where they exist because of the physical properties of the respective areas. They have evolved as self-sustaining communities adapted to particular regions, where they efficiently harvest energy ultimately derived from the sun and regulate the cycling of nutrients. Modifying all communities worldwide into simplified ecosystems and monocultures has had locally disastrous results. Although such monocultures work well in temperate Europe and North America, they may or may not be appropriate for tropical lands or other situations that are now being exploited by a rapidly expanding human population.

With such a small proportion of biodiversity known and with so many economic advantages to be gained by appreciating and utilising it better, it should already be apparent that there are enormous advantages in understanding biodiversity better and utilising it properly. The explosive growth of our human population, however, which has increased from 2.5 billion in 1950 to nearly 5.4 billion today, with two to three billion people to be added in the next quarter century, over 90 per cent of them in developing countries, is pushing increasing numbers of species of plants, animals, fungi, and microorganisms into extinction. I concur with and partly have helped to generate estimates that some 20 to 25 per cent of the world's biodiversity may disappear permanently within the next 25 to 30 years. Such a loss would not only represent an unacceptable outcome from an aesthetic, moral, or ethical standpoint, but it would represent a permanent scientific loss and a severe curtailment for human development in the future. Although the United Nations estimates that world population may, if current levels of effort in relation to family planning continue, stabilize a century from now at two to three times its present level, it is clear that the next few decades are likely to be the most tumultuous, threatening, and damaging to the continuation of biodiversity that we shall ever experience. The 1990s and the first few decades of the 21st century, therefore, are ones in which particular attention to this field must be paid if human options are to be protected adequately for the future. In order to achieve these objectives, we must have an adequate base of knowledge, appreciation, and understanding, because the opportunities that exist now are disappearing rapidly and permanently. From the considerations that I have outlined thus far, it should be apparent that I consider managing, understanding, using properly, and conserving biological diversity, which is the proper practice of systematics, as a matter of urgent human priority. I believe that the European Community ought to set up a system for dealing with European biological diversity, as I have suggested to relevant authorities there, and I am delighted that The Natural History Museum is now undertaking a data bank on European plants. That center will make an important contribution to the purposes just outlined.

Systematic and evolutionary biology has always been one of the strengths of the biological sciences in the United Kingdom. The collections held in The Natural History Museum, the Royal Botanic Gardens, Kew, the Commonwealth of Mycological Institute, and many other museums and university collections, are of world importance containing as they do type specimens and much other relevant material concerning organisms from throughout the world. Scientists everywhere have a genuine and continuing need to consult these materials, which are one of the important undercapitalized assets of British science.

As I have suggested above, the proper management of biological diversity throughout the world will depend on the proper arrangement of and provision of accessibility for knowledge about organisms. The UK collection holdings in museums and the related libraries built up at enormous cost over a very long period of time in themselves constitute a resource of world importance that ought to be utilized properly. They also constitute an enormous asset for the pursuit of science in the UK, in an age of extinction and one when biotechnology is making more accessible for purposes of all kinds the enormous genetic diversity of organisms. As to whether the level of systematic research in the UK is appropriate or not, you will have gathered from the foregoing remarks that I think that at this time of extinction, when the proper use of biological diversity has so much to offer for the human prospect, I believe a very large scale effort is called for. The major museums in the UK are under pressure to maintain the basic services

by which they can make their collections available for many purposes and to conduct the kind of minimum level of research that would assure their relevance. Whether this has fallen below the level that is acceptable or desirable, I am unable to state, but a few observations may be in order. Under separate cover I have sent you a report of our National Research Council from a committee that I chaired, which surveyed the field of biological sciences, including their relevance to agriculture, medicine, and biotechnology. You will note from this report the well-known fact that the infusion of molecular biological knowledge into biology has made many new and wonderful discoveries possible, and has literally rejuvenated many fields of biology that were falling behind or in which the problems had simply become intractable as a result of the inadequacy of traditional methods to approach the questions involved. What I would particularly mention about the conclusions of our committee, however, is that systematic and evolutionary biology and ecology are featured because of many of the same reasons that I have stressed earlier in this communication, and because those important fields require analyses of their own in order to provide the answers that science and society needs. Putting it differently, the application of molecular biology to the basic problems of biology, which has become the dominant and in many cases the only factor involved in the functioning of academic departments in the biological sciences in the UK, as in the United States, does not constitute an appropriate broad-scale approach to the field as a whole and does not constitute the kind of approach on which a secure future can be based. The UK, once clearly the leading nation in the world in the field of systematic and evolutionary biology, may or may not have fallen behind the United States overall to date: but given the fact that there are virtually no opportunities for training in this field in universities in the UK at present and that little attention is being paid to this problem while simultaneously funds are being cut from the major institutions in this field, suggest to me that the UK's ability to compete in a biotechnological environment in the future is being severely impaired. In addition, the UK's ability to contribute to our understanding of the biological diversity on which we all depend in an age of widespread extinction is rapidly being dissipated despite the traditional strong standing of the nation in this area and the enormous opportunities available for future growth.

As to whether British research in systematic biology is in the right areas or not, I believe that it is, in general, and that a broad scale policy of support stressing inventories in selected areas, computerisation, monographic work, paleontological studies, the application of molecular biology to particular areas, and the application of more refined methods of analysis to these areas are all appropriate and all are quite well represented in the UK at the present time.

I do most certainly believe that the UK has enormous responsibilities to the world's scientific community and indeed to humanity in general to maintain and curate the incredibly valuable biological holdings in the collections. I would judge that those obligations and responsibilities are being met at present but that this situation may soon change if support is increasingly withheld.

Concerning point (iv) in your inquiry of 17 April 1991, as I have said before, I am quite certain that British research in systematic and evolutionary biology is indeed backsliding on an international scale and that British opportunities for capitalising on biotechnology and making truly significant contributions to world science in this area are being diminished accordingly. New methodologies are being applied but opportunities are being decreased on a fairly continual basis. The level of funding available for research in these areas is relatively small and the priority being given to systematic studies in relation to other areas of biology is, in general, inadequate, although there have been encouraging trends over the past few years. Young people are not much attracted to enter these fields at present, since opportunities are properly perceived to be relatively limited.

In this connection, I should stress the fact that, for example, recent funding cuts at The Natural History Museum have been applied very wisely, in my opinion, by the management of the Museum in achieving efficiencies and opportunities for future growth on a much more satisfactory basis than was envisioned earlier. I do believe that these changes have the potential of enhancing the level of research and service given to the world's scientific community by The Natural History Museum, and I am thoroughly familiar with the situation in the Museum. If these potentialities are to be achieved, however, funding will have to be found somewhere, the institution now having been stripped back to what I regard as a strictly basic level, very wisely and courageously, but now badly needing support to achieve its proper world contribution.

I do not think immediately of any particular examples of how systematics, research, and training are conducted in the United States that would be relevant to your considerations now. Britain and the UK are clearly the two leading countries in this area, and we are suffering similar perceived shortages of funding and reallocations of priorities here. I do believe, however, that in the face of the world situation facing us all, that we must strive to improve our performance in these particular areas.

In conclusion, I am pleased to invite you or anyone connected with your Select Committee to visit us here at the Missouri Botanical Garden to see how our institution operates in the field of systematics. To this end, I am sending certain materials about our institution, which is familiar to the authorities at The Natural History Museum, under separate cover.

It has been a pleasure to contribute some points of view to your inquiry, and I hope that you will find at least some of these considerations and the materials I have sent separately helpful.

With good wishes for a successful inventory of this important area.

Peter H. Raven

Director

Note by the clerk of a meeting between L Dainton and Dr Peter Raven, Director of the Missouri Botanical Garden

In discussion, the following points were made:

Systematic Biology in the US

(1) While numbers of zoological taxonomists in the United States had declined in recent years, the number of botanical taxonomists had increased. Overall, the decline of taxonomy was only *relative*. In the United Kingdom the expansion of molecular biology had been at the expense of taxonomy, but this was not the case in the United States. As the appreciation of the task that lay before taxonomists had grown, there was nonetheless concern in the United States that resources were inadequate.

(2) Under the aegis of the Centre for Plant Conservation, the United States carved up responsibility for endangered species between the various botanical gardens. Each dealt with the species within their territories and maintained seed banks etc. Funding was largely private.

Systematic Biology in the UK

(1) The switch away from systematic biology in the United Kingdom was a consequence of the underfunding of biology in general as compared with the United States.

(2) It should be possible for the United Kingdom to receive some overseas assistance to maintain its collections. If the United Nations were to receive more executive power on environmental issues, it might also become a source of funding.

(3) A 5 year earmarking of research monies for systematic biology in the United Kingdom would have a very beneficial effect.

General principles

(1) Systematic biology was one of the intellectual ways of approaching the issue of biodiversity. Biodiversity was the stock-in-trade for sustainable development. This was the strongest intellectual argument in favour of supporting systematic biology at present and was also politically appealing.

(2) Molecular biologists increasingly realised that they needed to know about systematics, and that this knowledge could not simply be acquired "on the hoof".

(3) The rate of extinction of species put a premium on maintaining natural history collections.

Recommendations for future action

(1) Each area/country should prepare a database on the lines of INBio, as in Costa Rica. The publication "Floristics for the 21st Century" listed 46 different professions which would use such information. This gave biodiversity and systematic biology in particular a present day relevance.

(2) The European Community should do much more to promote systematic biology within Europe as much is still needed to be done. Extension of European activity in systematics to Eastern Europe and Russia would be politically attractive. There were, for example, huge collections in St Petersburg.

(3) Aid budgets should increasingly be used to develop systematic expertise in developing countries.

(4) The World Bank's Global Environment Facility could be used in support of systematic biology in developing countries, and this should be pursued with the Bank during the Committee's visit.

(5) It was important to encourage universities to become more involved in systematics. This should be done by external funding.

(6) Museums should be discouraged from undertaking basic research. Their role was to provide intelligent curation of their collections.

Evidence from B J Richardson, Survey Director, Australian National Parks and Wildlife Service

The task of managing the Australian environment is shared between the Federal and State governments for constitutional reasons. This situation creates the potential for problems in the collection, analysis and use of environmental data on a national scale. Two programs run by the Federal government exemplify some of the strategies that can be used at the national level in a federal system. The programs are the Australian Biological Resources Study (ABRS), which has been running for some years, and the Environmental Resources Information Network (ERIN), a recent initiative of the Federal government.

Australian Biological Resources Study

During the 1970's, the scientific community in Australia recognised the coming crisis in the identification and conservation of Australia's biodiversity. As a consequence, the Australian Biological Resources Study was established by the federal government to coordinate the collection and to make available the needed information on Australia's flora and fauna. Over 400 scientists around Australia and overseas in Federal, State or other agencies are involved in the program of research and documentation. None of them work for the Australian National Parks and Wildlife Service, the agency responsible for coordinating the program.

The ABRS aims to answer the questions "What species of plants and animals occur in Australia?" and "Where do these species occur?" The work is carried out in taxonomic institutions Australia-wide and support is through a competitive granting scheme. The work, which has been under way for almost twenty years, is given strategic direction by an Advisory Committee of professional scientists drawn from a range of institutions. ABRS is managed by a small unit of professional scientists within the Australian National Parks and Wildlife Service. Along with their coordination role the unit manages the integration of the resulting research in to databases of information and books. A critical role played by ABRS has been the establishment of interchange standards for museum and herbarium collections. These standards have now been in place nationally for ten years and are accepted by all significant taxonomic institutions in Australia.

Since its inception the ABRS Advisory Committee has sought to carry out its objectives in the following fashion:

The first task was to determine the size and nature of the problem. In summary, only 100,000 of the estimated 300,000 species of Australian animals have been collected and described. In the plants, 18,000 species of higher plants have been described out of an estimated 24,000 species. The number of lower plant species (fungi, mosses, algae, etc) is unknown. The distribution of available information between taxonomic groups does not match the needs of decision makers, as the larger and more showy species have been described while the smaller forms that, for example, build, replenish and stabilise soil or are potential biological control agents, are mostly unknown. More seriously, the survey found that Australia has very few scientists able to study these smaller organisms.

The ABRS Participatory Program is a goal-directed grants program supporting the documentation of Australia's biodiversity. To date more than 750 books and scientific papers have been published with ABRS support.

The grant funds (\$2 million in financial year 1991/2) are used to direct the taxonomic effort towards national goals set in consultation with the scientific community. The funds are used to support research on selected groups by experienced scientists or to train workers to study those groups where expertise is not available.

The biological information collected is made publicly available in the form of a range of books. Some of these are technical, such as the Flora of Australia and the Zoological Catalogue of Australia, while others are meant as references for a wider market including the interested amateur and senior school students, such as the Fauna of Australia and several Atlases. While the Catalogue appears in book form, it is in fact a database that has been specifically designed to allow for rapid updating as taxonomies change.

A systematic effort has been made over many years to support the mapping of the vegetation of Australia at a useful scale. Tasmania, Western Australia, Northern Territory and parts of Queensland have been completed or are in progress.

The plant and animal collections held in museums and herbaria are key sources of information on the past and present distribution of species. ABRS has supported the development of standards and the databasing of specimen information in many institutions. As a consequence of this a national system allowing the integration of information from many institutions is in place.

Lessons from ABRS

Some of the keys to the success of ABRS are easy to discern. (1) The federal nature of the system of government has been taken seriously and no attempt has been made to duplicate State instrumentalities. (2) A small organisation staffed by scientists who have the respect of the professional community was

established in Canberra to coordinate the program. (3) An Advisory Committee representing the major user groups oversees the program and reports to the Minister on progress. (4) The bulk (85%) of the funds are distributed through a goal-directed grant scheme and are not available for use by the coordinating unit. (5) Neither the ABRS Advisory Committee nor the coordinating unit have the authority to force anyone to work on particular projects. They can only inform and work through consensus.

Because of these strategies, ABRS is not seen as a competitor by other sections of the federal system. As a consequence, a national program is carried out which sees an orderly approach to the task of collecting and making available, in a systematic and efficient manner, the biological data needed by the various levels of government.

Environmental Resources Information Network

The problems that result from the absence of adequate environmental information necessary to underpin federal decision making have become evident in the past few years. As a consequence, the Prime Minister, in his 1989 Statement on the Environment announced the establishment of ERIN "to draw together, upgrade and supplement information on the distribution of endangered species, vegetation types and heritage sites." The program was to use recently developed computer-based tools to combine, analyse and display such data in the form of a Geographical Information System (GIS).

The aim of ERIN is to provide geographically related environmental information of an extent, quality and availability required for planning and decision making.

The following progress has been made in the ERIN project:

Administration—A Steering Committee of environment portfolio users has been established to ensure the network meets their needs. This Committee considered the results of a detailed study, made by consultants, of the Portfolio's needs for environmental information for decision making in establishing priorities for ERIN. The ERIN Unit, consisting of environmental scientists and computer analysts, has been set up.

Continental GIS—During its initial phase (until June 1992), ERIN's main project is to construct a GIS of the Australian continent. This GIS will focus on the biological environment, and will use comprehensive, reliable data and the best possible resolution. It will provide coverage at a scale of 1:1,000,000 and concentrate on layers for vegetation, environments/ecosystems, flora, fauna, natural heritage, climate, wilderness and public lands. A typical application will be to predict the distributions of endangered or vulnerable species and determine whether they are adequately represented in existing conservation reserves. Collaboration with the National Resources Information Centre in the Department of Primary Industries and Energy will avoid duplication in effort or cost; and will enable other fundamental data to be included, such as geology, soils and land use. Finer scale GIS's for particular regions (see below) will be developed through collaborative projects.

Satellite monitoring—Continental monitoring will be achieved through NOAA AVHRR imagery (1 km resolution). An Australia-wide cloud free mosaic consisting of five channels of data will be obtained every two weeks. Initially the outputs will include continental-wide coverages of major bushfires and of the normalised difference vegetation index (NDVI) to monitor vegetation change.

Species distributions—Providing information on the distribution of flora and fauna, and on the processes affecting those distributions, is a central role of ERIN. Priority has been placed on endangered and vulnerable plants and animals, landcover plants, remnant vegetation and indicator species. To obtain these data in a cost-effective way, and to provide a basis for planning future surveys, ERIN's strategy is to begin by collating data already available from existing sources, such as the country's herbaria, museums, and nature conservation agencies, and will have over a million site-specific records in house by early 1992.

Cape York Peninsula—The Cape York Peninsular Joint Land Use Study, a joint project of the Queensland and Federal governments, aims to evaluate issues related to environment and resources on Cape York Peninsula. ERIN will collaborate in GIS development for the conservation and heritage aspects of the project.

National Index of Ecosystems (NIE)—The NIE aims to define, map and document Australia's environments and ecosystems as part of a government commitment to conserve biodiversity. The project involves collaboration with State and Territory nature conservation and land management agencies to ensure that the conservation status of all ecosystems can be accurately assessed.

Murray Darling Basin Index of Ecosystems—This project, which covers the largest catchment area in Australia, is a component of a large GIS being established for the MDB Commission. ERIN is to assess the conservation of important ecosystems and endangered and vulnerable species in nature conservation reserves in the Basin.

Environmental Decision Support Systems—ERIN is collaborating with Commonwealth Scientific & Industrial Research Organisation (CSIRO) Division of Information Technology to develop software for the crucial tasks of integrating, querying, modelling and analysing geographic information. BIOCLIM, a predictive system that relates geographical distributions to climate, has been installed and linked to ARC/INFO.

Databases—Datasets presently being loaded into ORACLE databases include the National Census 1981 and 1986, Census of Australian Vertebrates, the Australian Plant Name Index, the Census of Australian Vascular Plants and distribution records of rare and threatened species, major plant cover groups and key vertebrate and invertebrate indicator groups.

Directory Service—The directory system FINDAR, developed by the National Resources Information Centre, has been installed.

Currently it contains information on environmental datasets held by the portfolio. Other proposed directories include indexes of biological surveys and of environmental impact studies.

Database Design—ERIN's biogeographic and spatial databases have been designed, and implementation is in progress. The design accommodates facilities to handle the absence of and competition between standards, and also lineages of data sets. The major modules will be progressively implemented over the next six months. The spatial data base provides links between attribute data and the GIS package, ARC/INFO.

Data Standards and Transfer—Implicit in ERIN's role of coordinating data base development is the need for national data standards and for agreements on data exchange. Workshops, for example on fauna habitat and vegetation site survey standards, are useful forms for evolving a consensus on acceptable standards. ERIN is collating information about existing standards for biological surveys. Consultations about core attributes, interchange, quality control, and data models are continuing with relevant groups.

Computing Facilities—The computing platform consists of SPARC stations networked to a SUN 4/390 file server. The graphical user interface is Open Windows (X-Windows standard). Basic tools include ORACLE RDBMS and SIRO DBMS (databases) ARC/INFO and ERDAS (GIS), S+,PATN, and CART (statistics and modelling), and Simplify SQL (graphical interface). Care has been taken to ensure compatibility with facilities at the National Resources Information Centre.

Networking—As implied by its name, ERIN is committed to develop a portfolio-wide network enabling widespread access to the environmental information contained in its databases. A strategy to implement a wide area network has been prepared and implementation of the first phase has begun.

A regular Newsletter is circulated within the Portfolio to keep people up to date and to educate them on the systems that will shortly be available to them.

Lessons from ERIN

The field of Spatial Information System development is fraught with problems. There are many different options available and a very large number of different data sets can be included in the system. As well, the system tends to be complex, difficult to use and the results obtained subject to easy misinterpretation by the inexperienced. For these reasons it is essential before starting to define the purpose of the system and to closely question the potential users as to specifically what questions and in what time frame they wish answers. In the case of ERIN, professional consultants were used with experience both in GIS use and in the sociology of carrying out such a user analysis. This step took 80 per cent of the start-up phase time and great self control was needed not to be "busy" purchasing hardware, software and data until these matters were settled.

An observation made during the user survey was the complete lack of understanding of GIS on the part of most of the potential users who are in policy areas, fear of the system and no concept of how it might be used by them. As a consequence, a systematic education program of potential users was started. This included simple information on what a GIS is and demonstrations of several systems that were set up to carry out the kind of analysis that users might need to do. The level of ignorance could be frustrating and every effort had to be made to avoid telling the users what they needed. It is envisaged that the education of users, especially in conceptually new ways to use such powerful new tools in making environmental policy decisions will be a major task of the ERIN unit.

A third important step was to place the program firmly under the management of a Steering Committee consisting of the line managers in relevant policy areas. This gave them a sense of ownership and the responsibility for ensuring it met their needs. These processes have converted potential users in the Portfolio from an attitude of deep suspicion and unhappiness in having to "waste time" talking to the consultants to one of some enthusiasm and support for ERIN. It remains to be seen whether useful products can be brought on line quickly enough to stop this attitude from flagging.

What must be appreciated is that no one system and host organisation can handle responsibly all of the needs for environmental information and analysis. Gone are the days of mega-centralised computing. Present solutions lie in the direction of open systems and distributed processing combined with a broad range of backgrounds in the support unit. To this must be added extensive training and support for the user community, including senior management.

Evidence from Professor W. D. L. Ride, The Australian National University

The following submission is made in response to an invitation from the Committee.

Introduction to Submission: I am grateful to the Committee for seeking my opinion on the matters before it because I am closely involved with them and have both a personal and institutional interest in their outcome. During the whole of my professional life as a working systematic biologist I have been much involved with taxonomists in the United Kingdom, with UK institutions, with their collections and with the products of more than 200 years of research carried out by them on the Australian fauna.

My initial involvement in systematic biology in the UK was as a research student in the University Museum, Oxford, and working with collections of the British Museum (Nat. Hist.).

Subsequently, as Director of the Western Australian Museum, I made collaborative arrangements with the Brit. Mus. (Nat. Hist.) for collecting and research and, on my own account, have continued to use the collections and consult with staff.

As the first Director of the Australian Biological Resources study, I took into account British experience at the time I was setting up our own organisation.

Finally, as President for an number of years of the International Commission on Zoological Nomenclature (which maintains its Secretariat at the Natural History Museum), I have had a continuing involvement with British effort in zoological nomenclature.

The views in this submission are expressed in the order in which they are listed in the Committee's invitation of 2 May 1991. In commenting on the points raised, I do not repeat what I have already said to the Committee in the submission that I made earlier on behalf of the International Union of Biological Sciences (IUBS) unless I have found it desirable to extend the comment made there.

Views

(i) *Level of systematic research:* The level (i.e. standard) of British published research is high. This results from an almost universal acceptance by British science of the processes of peer review. Research papers by British scientists occur in all major referred international publications in this field. I know of no complaint about standards.

I cannot provide objective data on the question as to whether there is an appropriate volume of published research. Britain is a leader in biological science and British scientists have an unparalleled data base in the national collections and by comparison with many countries the research budget is high. On these grounds, taken together, Britain should be a world leader (if not the world leader) in the field. Yet I have an impression from the literature I scan that the output in systematic biology is far below that of the United States. With the cooperation of such an organisation as BIOSOS-UK, it would not be difficult for the Committee to test this statement with objective data—even with relatively slender resources. I refer to the question of ways of increasing national effort below (under (vi) Australian experience).

(ii) *Areas of systematic research and setting priorities:* As you imply in your question, before one can determine whether research is in the "right" areas there must be some national policy—or, at least, determined objectives against which to measure achievement.

If your Committee is prepared to argue for national objectives in systematic biology, as I hope it will, I would suggest that there are three obvious areas that should be provided for by the objectives. They are:

- (a) *Areas in which a national need for taxonomic infrastructure is demonstrated.* There is a long history of economically motivated taxonomic work in British agriculture. A well known example is provided by taxonomic research into nematodes at Rothamstead. Today, reliance on chemical pest control, combined with the very high productivity of British agriculture, has led to reduced efforts in this field and a sense of false security.

From papers given at the recent (1990) symposium on biodiversity sponsored by CAB International, held at the Royal Society, there is clearly a neglected field in microorganisms and invertebrates concerned with soil fertility and of relevance in biological control. If you have not already approached him, Professor David Hawksworth of IMI, one of the organisers of the Symposium and editor of its proceedings, could give expert advice.

Research to discover organisms that are particularly sensitive indicators of environmental health is also a little developed field of applied systematics. Yet it is one that is going to demand increasing attention in the future.

Research to support conservation planning and to determine the effectiveness of existing reserve systems and conservation legislation will assume major importance in Britain, as elsewhere throughout the world. Current awareness of the need to maintain biodiversity will increase demand. Currently only a small fraction of the information on which to determine priorities and base action is available.

The establishment of national priorities in areas of applied systematics invites the view that such work should be carried out under government direction in government departments and instrumentalities. However, it has been our experience in Australia that there is much available systematic research effort in universities and other independent institutions that can be tapped if the right funding mechanism can be developed (see (vi) below). If properly managed, contracted systematic research can be arranged in a way that makes better use of a scarce national resource (at present underutilised) and at lower cost than research that relies *solely* on government machinery. However, it must be emphasised that the collections that such research relies upon (and are also a product of it) must be properly protected, in the long-term national interest, as an ongoing resource.

Indefinite and secure management of collections and their information data bases is not usually regarded as an acceptable role by universities and most research institutes. Such collections require statutory protection. Therefore a high degree of integration must be achieved between contracted parties and those government institutions (museums and herbaria) responsible for maintaining the national data base.

- (b) *Areas in which Britain is particularly well equipped to conduct research irrespective of national boundaries.* Because of Britain's maritime and imperial past, British scientists were the first to collect and work on taxonomic problems in many parts of the world. As a result of this pioneering work, British collections of 19th Century biotas are without rival in their richness and form the foundation of much international systematic biology. There is no doubt that over the last 50 years British effectiveness in international research in areas in which she was previously the leader, has fallen off markedly. This would not matter if international science had filled the gaps, but I regret that this has not been the case in most developing countries, although the USA, in particular, is playing an effective and prominent role (see IUBS submission).

In the case of the former Dominions (such as Australia), the lack of British research matters less because most of them are conducting sophisticated programs in systematic biology adequate for their own needs. However, this does not remove a requirement for Britain to continue to provide an interface between overseas scientists and the collections in Britain on which they require continuing advice and access (see (iii) below).

There is no doubt that the cost of work in maintaining and researching international collections borne by scientifically sophisticated countries should be regarded as a form of international aid—and not as a form of scientific self-indulgence. The fact that it is not regarded as component of overseas aid programs, is a comment on the lack of understanding by treasuries and political systems of the indispensable infrastructure that such work provides for all biologically based development. To a large measure systematists (and those directly administering them) have only themselves to blame for this.

- (c) *The need to encourage and maintain expertise in systematic biology.* Because systematic biology provides the basic information infrastructure in biology, it is unthinkable that British science policy would not require that a high national capacity in this field be maintained. In the past a reasonable level of biosystematic expertise and training has been provided automatically by the presence in the scientific institutional structure of a number of government funded and government sponsored research institutions with objectives wholly or partly in systematics. Some have been in applied systematics (e.g. the International Mycological Institute and Rothamstead), others have worked mostly in the non-applied field (e.g. the Natural History Museum and the Royal Botanical Gardens, Kew). In addition, there was always a proportion of systematic biologists in the universities, with their research funded from untied funds within the academic structure.

Nowadays, with requirements that a high proportion of research must be grant funded (which shifts emphasis from long term and unapplied research towards problem solving research at the tactical end of the research spectrum), there is a real danger that funds for systematic research, and recruitment into systematics, will dry up unless there is a deliberate policy to maintain effort in this field (see below).

(iii) *International need for British reference collections:* In my submission on behalf of IUBS I made the case that the British reference collections are an indispensable tool for international systematic research because most can never be repeated due to changed circumstances; moreover they contain huge numbers of type specimens. I have also replied in the IUBS submission to your questions about responsibilities and obligations. As an Australian, I must add that I consider that those managing the British national collections also have a special responsibility towards the scientists of former British territories. Not only did Britain (controlling the resources) collect freely within them but, because of the maternal relationship, many of the resident scientists working in those territories regarded the British Museum as the "natural" place to deposit all, or part of, collections made by them.

In the past the curation and storage of the British national collections with which I have worked has been on the whole acceptable by the standards of the time. I have not personally worked within the collections of the Natural History Museum since the 70s and at that time the collections were not

computerized. Today, for such collections to be accessed and managed with ease (as is required by international and external use), data must be held in machine readable form and conformably with agreed international exchange standards.

The Committee should certainly inquire into this aspect of collection management of the national collections and if the funds are not available, I would ask that the Committee should give consideration to recommending the establishment of a program to progressively bring the data (on the international collections at any rate) into an electronic data base. International exchange formats have already been agreed for plant groups, but funds that would enable their adoption in the U.K. have not been available. Certainly, if interactive data bases were established for major British institutions in the same manner as international library data bases have been, information on the British international collections would become generally available through international science networks.

There should be no shortage of advice to the Committee on this aspect from within Britain. The Museum Documentation Association (Duxford, Cambridge), is internationally recognized as a pioneer in this field. The Institute of Terrestrial Ecology (Monks Wood Experimental Station) was a world leader in this field (and was an important source of valuable advice to me, especially on geocoding locality data, when I was establishing the data bases of the Australian Biological Resources Study—see below), but I understand that its systems have now become obsolete through lack of funds.

The Department of Biology of the University of Southampton (Dr Frank Bisby), CAB International and the International Mycological Institute, and others, have been involved in developing interactive programs whereby such data bases may be interrogated. They, and the Museum Documentation Association would probably be the best current source of advice to the Committee if it wishes to pursue this line further.

Finally, there is a widely perceived threat to the staffing of the British international collections. Assurances have been given that curatorial facilities will be maintained so that the collections are not physically endangered. But from what I have said above, this is only part of the problem. The Committee is asked to recognise that while Britain maintains her self-appointed custodianship of the irreplaceable international collections at the Natural History Museum and Kew, the international scientific community will ask for interactive access to information on the collections, and the scientific cooperation of experts familiar with the taxonomic issues that they represent (see comments under (v) below).

(iv) *Current status of British systematic biology and the impact of new methodology*: The current status of individual workers remains high but there is no doubt that for innovation in systematic biology nowadays one looks primarily to the United States. The slide is not recent. In my special field (taxonomy and palaeontology of higher vertebrates) in which Britain had undisputed dominance in the 19th Century, after a period of stagnation in the first few decades of the 20th Century, taxonomic theory based on advances in genetics and statistical theory gained momentum in the United States in the 40s and 50s—especially with Mayr and Simpson at Columbia, at the American Museum of Natural History, and at Harvard. This momentum has continued with such innovative workers in new areas, such as Sibley in comparative serology, and a host of others in fields such as computing and cladistics.

However, while the bulk of progress is coming from the United States, a steady flow of good published work continues to come from British scientists, much of it innovative in new systematic methodology. Professor P H A Sneath, formerly of the Department of Microbiology, University of Leicester has been outstanding in developing microbial systematics and should be consulted by your Committee on needs in Britain resulting from new methodology; especially on needs for culture collections, some of which appear to be in financial difficulty. I understand that the precious and vast collection of bacterial cultures built up and studied by Professor Sneath himself (and surely a national asset of great value) has an uncertain future.

I have no first-hand experience that would enable me to make judgments of the sort required by your specific questions (a)–(e). However, having been responsible for conducting a review for the Australian Government some years ago (see “Towards a National Biological Survey”—Attachment A) (not printed), I believe that the information sought is fundamental to your inquiry and, if acted upon, could change the face of systematic biology in Britain—as it has done in Australia.

(v) *Changes at the Natural History Museum*. I have had extensive contacts with the Natural History Museum for many years (see introduction, above). I am also aware of the changes taking place. I have no doubt that they will enhance some aspects of the level of research and service given by the Museum to the world scientific community, but I also think it likely that other aspects of its service will suffer. The Director and Trustees have assured the community that the collections will be maintained, and will remain accessible, but there is no doubt that the planned consolidation of coverage of systematic research will result in reduced expertise overall. As a result, capacity will be reduced for dialogue between the custodians of the collections and scientists working in other institutions in fields no longer covered by research staff.

Moreover, from the official papers it is clear that, concurrently with reduction in overall research effort due to financial stringency, a significant part of scientific effort in the museum is being diverted into areas of biological science other than systematics. While I can appreciate the desire of the Museum

to expand its own information base (and, possibly, to move into areas more capable of attracting grant monies), as a developer of museum policy at the national level, I can only comment that from the wider perspective I am surprised that such a use of scarce personnel resources has been authorised while unique "plant" (ie, the collection) remains underutilised.

Fears for the service that the Museum can give, and that the same pressures may produce a flow-on at Kew, have produced wide reactions. While, in part, these reactions are bound to represent an expression of solidarity by taxonomists with their colleagues at the Museum, and are liable to be dismissed by the authorities on that account, nevertheless, there is a real fear that Britain is pulling away from her international responsibilities. I attach correspondence expressing these fears (Attachment B) (not printed) from the Joint Committee on Museums of the Australian Academies (on which I represent the Australian Academy of Technological Sciences and Engineering).

An aspect of a reduction in coverage concerns the capacity of the Museum to fulfil its commitments to joint work agreed between the Museum and other institutions and individuals. In the case of one agreement that I negotiated many years ago, the reduction of effort in London has resulted in difficulties to Australian research workers dependant on the collections made under the agreement. The case has produced a hostile reaction in Australia (Attachment C) (not printed). I would be surprised if the case is unique.

As a former Museum Director, and former Council Member of two Australian national museums, I have great sympathy for the Director and Trustees of the Natural History Museum. From my knowledge of individual scientists at the Museum, from having worked with them, from the official correspondence I have seen, and from various generations of corporate plans, I am convinced that change had to come to meet the needs of both public programs and scientific research. But, at a time at which systematic biology requires increased expenditure in basic research, and international science requires support from the holders of the major taxonomic data bases, the measures adopted seem to be unsympathetic to these needs. Even if a solution can be found to difficulties of maintaining access and dialogue in areas not covered by the areas of concentration, I would also like to feel secure that the measures adopted would not result in serious long term consequences to basic research and recruitment in systematic biology in Britain. Such consequences are the predictable outcome of institutional policy channelling scientific effort into research areas capable of attracting outside research funds.

In the case of taxonomy, funding bodies supporting research rarely, if ever, have among their objectives responsibility for the wider welfare of systematic biology (see comments under (vi) below) and require research results with short term objectives.

On the basis of our experience in Australia, I would be less worried if you had in Britain a funding body with a specific responsibility to support taxonomy. I am not suggesting that the Natural History Museum should return to its former organisation, or that its research staff should not be required to compete with those of other institutions (such as universities) for research funds. Instead, I suggest that the Committee should give consideration to seeking that some part of overseas aid (see p 4) and of the science research budget be allocated specifically to meet needs in systematic biology recognising that, while some kinds of taxonomic work can compete successfully in applied science, and others that are innovative in exploring new processes can compete successfully where the criteria for success are outstanding quality and originality, most of the taxonomy that builds the infrastructure of biology (and that is endangered by current economic trends) is of the workmanlike sort that adapts and applies perfectly well understood techniques to different groups of organisms. The support of such research has been provided in the past by normal institutional budgets, and is carried out by curators. But nowadays, even in museums such research is looked down on by managements as self-indulgent. Accordingly it competes poorly with the pressure to support new and necessarily expensive public programs.

Periods of financial stringency may also provide an opportunity for institutions to rid themselves of unproductive staff and restrictive employment conditions of tenure. I would be surprised if this has not happened in the case of the Natural History Museum. If this is the case, and research staff numbers have declined in the clean up, I would hope that the Committee will encourage the Government to seek from the Trustees a development plan by which they will gain, over time, staffing levels appropriate to full exercise of their international responsibility.

The question has been asked of me whether countries such as Australia, from which the collections of the Natural History Museum were derived, might make a contribution towards their maintenance in London. I have no doubt that the answer of most would be that the return of the collections to where they would be used would be the preferred option. Curatorial facilities in Australian national collections are certainly the equal of those in Britain and the international community need have no fear for maintenance or access. If there is any possibility that the diminution of effort in Britain is to be a permanent arrangement, and the international role no longer fully supportable by ongoing participation, the Committee might well consider that Britain's obligations to science might be served by relocation in countries which could guarantee satisfactory performance.

Recognising that such a solution would not be in the best interests of science because there should be some major international collections in the world where there is a capability to compare different faunas, consideration could be given to adopting a distributed model for the national collection and locating

major natural groups of it in Edinburgh and Cardiff. Besides distributing the cost of the international service, such a solution would also break down the isolation and the exclusiveness which has been apparent in staff attitudes within the Natural History Museum to other institutions. Development of a distributed information network, which would be a necessary correlate of such a decision, would force the national research capacity into an interdependent mode which would greatly benefit the national, let alone the international, functions.

(vi) *Relevant aspects of funding systematic research and training in Australia.* A very brief outline written by me for a British audience, in 1982, of the institutional position of systematic biology and collections in Australia is given in Attachment D. An outline of the development of specialised funding support for a national program of systematic biology, written by me in 1978 is given in Attachment A. Today, with considerable progress made in implementing the programs described therein, and in amplifying and extending them, the conceptual structure remains substantially the same.

The programs of the Australian Biological Resources Study (ABRS) are successful by comparison with any national programs in systematic biology, anywhere. Current political interest in the environment and biodiversity has resulted in recent incremental growth. The ABRS programs are now included within the responsibility of the Director of the Australian National Parks and Wildlife Service advised by a scientific advisory body. Its executive arm is the Australian Bureau of Flora and Fauna. The Bureau is responsible for coordinating the programs and for the published output and the maintenance of the national data base which, politically, together constitute the formal output of ABRS. The published outputs are the *Flora of Australia*, the *Zoological Catalogue of Australia*, and the *Fauna of Australia*. These are ongoing and will be subject to continuing revision. The national computerised data base, the Environmental Resources Information System (ERIN), is compiled and maintained by a network of contributing institutions under specified standards. Information is fully machine exchangeable within the network. Moreover, in addition to providing data of known distributions of species, the data base is now a predictive tool capable of using climatic data to predict distributions of species.

As well as advising on the ABRS programs, the advisory committee also advises the Minister on the allocation of grants from the ABRS Participatory Program. These grants are awarded for taxonomic studies in areas according to priorities set by the committee. Priorities are set according to the needs specified by the Bureau for systematic research needed to provide the scientific basis of the works listed above. Recently, high priority has been given to research on organisms of importance as biological indicators of environmental change. Proposals may also be made to the advisory committee to vary the priorities to take advantage of worker availability (often these are visitors working in Australia for short periods).

Staff of State and national institutions are eligible for grants, as are individuals. Post-graduate research projects are admissible. In addition there are no restrictions on individuals seeking funds from other funding sources (such as the Australian Research Council which funds academic research irrespective of field of study, or such bodies as those funding research in specific areas such as marine research, or environmental investigations).

Currently the Participatory Program stands at about Au\$2 m. per annum. In addition, support for ERIN stands at about \$0.75 m. p.a. The annual level of the Participatory Program is expected to increase by a further \$0.4 m. in 1991/2.

The success of the ABRS operations may be increased by the number of research scientists committed to research in systematics. Currently, it is believed that the Participatory Program could be doubled if there were to be a policy of funding all available personnel resources without lowering the present standard.

Further information on the current details of ABRS, and the policies governing its operation, can be obtained from Dr Peter Bridgewater, Director of Australian National Parks and Wildlife Authority (and my immediate successor as Director of ABRS), and the current Director of ABRS, Dr B J Richardson.

In my opinion, the most important outcome of the ABRS program has been the effect it has had in raising the status of taxonomists in Australia over the last 15 years. Looking back, some 10 years after I made my investigation of the status of taxonomy and the extent of taxonomic effort available in Australia (and, at the same time developed the forerunner of the ABRS Participatory Program), I said

“one of the most heartening things to come out of the investigation was the discovery that taxonomy was no longer a cinderella science . . . As long as the purpose of the work is to define the species and other taxa, it matters little what tools are used. When the circulars were sent out, people were invited to call themselves taxonomists if that was what they were, irrespective of whether they also called themselves anatomists, immunologists, geneticists, biochemists, biogeographers or biostatisticians. And this is what they did in surprising numbers. Perhaps it was in the hope of being funded, or perhaps it was a recognition of the new respectability that taxonomy had achieved. It does not matter. In the fact that many were students lies the most heartening promise for the future of taxonomy in Australia.”

Currently Dr Richardson and the ABRS staff are conducting a new survey to gain up-to-date information on the resources (both personel and collections) currently committed to Systematic Biology in Australia. I am confident that it will present an even more optimistic picture than the one I found 15 years ago.

In my frequent meetings with systematic biologists in the United Kingdom, I have gained the impression that my British colleagues today regard themselves as embattled, unsupported professionally, and underfunded, to a degree I do not experience in the United States or in Australia. In this milieu, I would be surprised if any but the most strongly motivated research students of high quality would choose to enter systematic biology as a profession.

If I am right, it poses a bleak future for systematic biology in the United Kingdom. And it would not take much to set it right and enable Britain once more to play an appropriate role in this crucial part of biological science.

W D L Ride, AM, FTS, MA, DPhil.

Emeritus Professor, Visiting Fellow, the Australian National University

Evidence from Sir Ralph Riley PhD, DSc, LLD(hc), BIBiol, FRS

1. This submission is made at the request of the Sub-Committee from my background as an agricultural biologist with experience in the practice and management of agricultural research in the UK and in developing countries.

2. The most important point to make is that all biological research depends upon the correct identification of the taxon in which the organism being studied is placed. It is only in this way that the results reported can be repeated and potentially "falsified". The correct definition of the taxonomic position of organisms can only be derived from systematics research. From this it can be concluded that systematics underpins the whole of biological research. The reason why the importance of systematics is often unrecognised is that much current biological research, especially in biochemistry and molecular biology, concentrates on a very few species of phage, bacteria, fungi, insects, mammals and plants. Expansion and the wide validation of this work will require the availability and definition of other taxa which will enable the diversification of the range of phenomena studied. It was J. B. S. Haldane who said "Treasure your exceptions".

3. Before a plant variety can be released commercially it must satisfy the UK statutory requirements and E.C. directives as being "distinct, uniform and stable". Thus a form of systematic study is continuously necessary on the descriptors by which distinctness can be defined. Distinctiveness and its recognition can have very great financial implications for plant breeders in both the private and public sectors in the UK and in the opportunities that UK varieties have to earn royalties from other countries who are signatories of the UPOV Convention (further details on these matters should be sought from the Plant Variety Rights Office of MAFF).

4. The level of commitment paid to systematics has declined in both teaching and research in many universities. Consequently it is only vigorously pursued in our major botanic gardens and in the NHM. However the research and the collections upon which it depends, can be vital in some situations. An example of this concerns biological control of the cassava mealy bug in Africa, Cassava (*Manihot esculenta*) is a native of South America which was taken to Africa by the Portuguese in the 17th century. It is now the carbohydrate staple of about 200 million people in about 20 countries of sub-Saharan Africa. In the early 1970s a mealy bug appeared which spread quickly with devastating effects on cassava production. The mealy bug was unknown to science but research showed that it was present but rare in Paraguay and Brazil. A search was launched for the predators which controlled the numbers of the mealy bugs in South America. Numbers of apparent predators were discovered but they needed to be identified and checked out for other potential hazards they might cause in Africa before being sent on to the International Institute of Tropical Agriculture in Nigeria. All this work on the systematics of the insect predators of the mealy bug was undertaken in the Department of Entomology at the NHM and the predators were multiplied by CABI Institute of Biological Control before transmission to Africa. The tiny wasp *Epidinocaris lopezi* proved to be the most effective predator. It has been widely released, often from aircraft, throughout Central Africa. Now the mealy bug is under control in places where insecticides could never have been afforded even if there had been a supply of water for dilution prior to knapsack spraying. Without the UK capability in insect systematics this programme could not have been successfully and safely carried out.

5. I am unable to discern whether the current balance of the UK work in systematics and in the maintenance of collections, whether preserved or living, is satisfactory. Perhaps the only way to ascertain this would be to poll customers to quantify the use as between different collections. Certainly so far as living collections are concerned perhaps evidence should be taken from BTG, (I am a member of the Council) which pays certain universities to maintain collections of micro-organisms from defined environments. Companies pay to have access to the collections with further agreements to deal with the identification by the company of any commercially useful product from a member of the collection.

6. Care should be taken in relation to living collections not to take decisions on the basis of the value of a living collection for systematics purposes which neglect its possible value for conservation. The Brundtland Report drew particular attention to the significance of sustainability. Part of sustainability

involves the conservation of natural diversity. Living collections constitute one means of maintaining genetic diversity. The importance of collections for this purpose is emphasised by the Consultative Group on International Agricultural Research (CGIAR) under whose auspices the International Board for Plant Genetic Resources operates. A UK citizen, Dr. Geoffrey C. Hawtin was recently named as the next DG of IBPGR. In addition many of the International Agricultural Research Centres (IARCs) of the CGIAR maintain large collections of crop genotypes and of genotypes of the wild relatives of crops. For example the International Centre for Agricultural Research in Dry Areas (ICARDA), on whose Board I serve, has more than 80,000 entries in its germplasm bank. While the International Rice Research Institute, on whose Board I formerly served, has in excess of 100,000 entries in its germplasm bank. Internationally, therefore, germplasm conservation is accorded high priority. The UK makes only a modest contribution to this activity and it would be very sad if an attempt to "rationalise" systematics were to lead to any diminution in our contributions to conservation.

Evidence from the Smithsonian Institution

Your request addressed to me concerning systematic biology research went astray as I think you will have learned. I am sorry for the delay, but will try to give you my thoughts on the questions you have raised. In some cases, my views have to be considered superficial since I may not have a detailed knowledge of some of the areas that you are investigating.

- (i) My experience with the volume of systematic biology research in the UK is that it is currently not large. How to determine an appropriate volume is difficult, but in terms of national and international needs, I think it is evident that the knowledge that is dependent upon research and systematic biology is absolutely fundamental in our understanding of the earth's ecosystems and their function. This knowledge is woefully inadequate at present, and will be critically important in the near future, if indeed it is not so now. In both the UK and the United States, systematic biology has not fared well in the last several decades in competing with other biological disciplines. I trust that this is changing, and I see some signs of it.
- (ii) The answer here depends upon one's views of national versus international responsibilities. Clearly, each nation has a responsibility for developing the scientific database that will allow it to understand biological diversity within the country and to develop strategies that will conserve and restore ecosystems and their diversity. However, countries such as the UK and the United States have a further responsibility to attempt to assist Third World countries. The biosphere is indivisible, and ecosystem degradation has effects far beyond the boundaries of the country in which such degradation is occurring. Within the country, the UK has important expertise of high quality, that ought to be targeted for assistance to foreign countries, particularly certain tropical countries that were once a part of the British Empire. The UK is the most logical choice to develop cooperative relationships with such countries and their developing scientific infrastructures.
- (iii) The British Museum (Natural History) is arguably the single most important museum serving the international community of systematic biologists. In my experience, the storage of its collections is for the most part very good, but the number of curators available, particularly to deal with incoming material is inadequate. The UK certainly has a particular responsibility to the international community as a result of the history of the British Museum and other similar collections in the country. I fear that the obligations that the UK has in fulfilling its international responsibility, not only for curation but for appropriate research and publication, is falling behind in the face of severe budget cuts and administrative reorganisations in one of the most important systematic museums in the country.
- (iv) One of the most important new methodologies in systematic biology research is that of molecular systematics. My sense is that systematic biologists in the UK are at best holding their own, or perhaps losing some ground in this area, particularly as compared with the United States. This may well be a matter of inadequate funding, since molecular systematics research is expensive. It is certainly, as I have indicated above, a result of systematics being in a poor competitive position relative to certain other areas of biology. The level and quality of training available to students, however, continues to be very high, and this should enable systematic biologists in the UK to improve their position in the future. The most encouragement that can be given to young people entering upon research careers in the field of systematic biology is the prospect of stable future employment. This is the greatest problem we need to overcome, not only in the UK, but also in the United States, and it relates to the several decade-long decline in the relative support for systematic biology in the recent past.
- (v) I have conducted research and have other contacts in the Natural History Museum (my earlier references betray my past history), and I am aware of changes that are taking place. I have to say that I am not convinced that these changes will improve the level of research and service to the international scientific community by the Natural History Museum. If there are insufficient professional curators/researchers associated with the museum, the collections will

over the long run suffer, and of course the in-house research that can be carried out will be significantly reduced. Finally, if the trend towards replacing curators/researchers with collection managers continues, there will be insufficient employment opportunities for the systematic biology community to carry out the essential work of understanding our biosphere that is so urgently needed.

(vi) The systematic biology community in the United States has recently made a serious effort to organise itself to promote the importance of systematic biology within the broader context of global and environmental change. This is done through several private organisations, such as the Association of Systematics Collections, and by developing *ad hoc* consortia to press legislative bodies for additional support for systematic biology research. One particularly active consortium at the present time is lobbying the US Congress for a National Centre for Biological Diversity. This sort of grassroots work on the part of scientists is, I think, very important.

I have been in touch with Professor Robert May, who told me that this letter might be arriving. In your appended note, you mentioned that some of the Committee may visit Washington in September. If you think I might be useful to your group if you do visit, please let me know. I would be happy to arrange for you to meet with various people at the Smithsonian Institution, the Association of Systematics Collections, and persons involved in biological diversity matters in the National Academy of Sciences—National Research Council.

Robert S Hoffman

Assistant Secretary for Research

Evidence from the Smithsonian Tropical Research Institute

Thank you for your recent letter requesting my views on issues relating to systematic biology research in the United Kingdom. I understand that you have also requested a response from Dr Frank Talbot, Director of the Smithsonian's National Museum of Natural History. Since the Museum of Natural History is the Smithsonian's primary bureau devoted to systematic biology. Dr Talbot's experience is more directly relevant to the issues involved. Dr Talbot is also chairman of the Smithsonian's committee for the development of a National Center for Biodiversity for the United States.

From my own perspective as a tropical biologist, it is obvious that a firm foundation of systematic biology is absolutely essential for effective research in organismic biology. This is especially true for the tropics, where so many species have not yet been described. Research in ecology, and on the effects of global change on ecosystems and biodiversity, requires accurate identification of the species under study, and failure to distinguish between closely related species can invalidate results. At STRI we have initiated a number of projects in biodiversity, among them our program in molecular evolution, which investigates genetic diversity both within and between species.

Perhaps the strongest recommendation I can make is that systematics programs in the UK should devote adequate resources to the study of biodiversity in tropical areas. With respect to the magnitude of work that remains to be done, the allocation of resources to date has been woefully inadequate.

It will be up to developed countries such as the UK, that have a longstanding tradition in systematic biology, to take the lead in documenting tropical biodiversity.

Ira Rubinoff

Director

Evidence from Thames Polytechnic

I have consulted several colleagues on your paper on this subject and our views are summarised in the following paragraphs.

Systematic biology research is an essential element of present day biology, contributing fundamental knowledge to many branches of biology, eg plant pathogenic bacteria, genetic banks, pharmacology.

There is a need to specify particular organisms in connection with intellectual property right, particularly in the area of pathogenic bacteria, which we have found to be important in our own experience at Thames.

At present there is a danger that systematic biology research is undervalued. British National Collectives are good but increasingly endangered. We have a responsibility to maintain the Collectives. UK research is good, but there is no overall strategic planning. New molecules criteria need to be applied to databases. Exploitation of information technology is patchy, an enormous amount of work remains to be done in this area, preferably within a general initiative.

The current institutionalised ban is probably appropriate but funding is insecure. There is certainly a role for industry in this respect, especially those with interests in pesticides, herbicides and the pharmaceutical industry, since they stand to benefit from this work.

Teaching is inadequate, this area of biology has been unfairly neglected in many modern biological syllabi. Perhaps the time is ripe for renewed interest in a revitalised subject. Much can be learnt from the USA and abroad in this method of funding and supporting this research.

Dr M C Cooper

Associate Head, Biological & Biochemical Sciences

Evidence from the University of Aberdeen

(i) Research in systematic biology is essential and fundamental to all branches of biology. It underpins studies in ecology, genetic resources, plant and animal breeding etc. In microbiology it is of particular importance because of the lack of a species concept equivalent to that of higher organisms.

(ii) In breeding studies it would be necessary to make clear statements about characteristics of plants, animals and microorganisms for patent application.

(iii) No. Systematics is grossly underfunded in UK Universities and where funding is provided it is often haphazard and poorly coordinated. It has a very low priority for funding amongst the Research Councils. It is difficult to estimate the appropriate volume but one means might be to assess the training opportunities in the subject which appears to be minimal, particularly at the postgraduate level. There should be specialists researching in all the major groups of organisms.

(iv) Present emphasis appears to be on novel methods of taxonomic research, such as DNA sequencing and fingerprinting, genome analysis etc. These techniques are extremely important but they should not be supported to the exclusion of traditional methods which are vital in basic studies of unexplored flora and fauna.

Guiding principles could be developed to produce a national policy. Ecological (for environmental impact analyses and for conservation studies) are as important as economic principles (production of chemicals from microorganisms). It may be necessary to make a survey of the resources and personnel available on a UK basis. The international role must not be forgotten as it becomes imperative to complete the floristic databases of countries with poorly known floras.

(v) Reference and type collections are essential but funding is inadequate for their maintenance. Because of the historic significance of our holdings we do have a responsibility to the world scientific community. As investment in taxonomic training declines the importance of collections becomes more important.

(vi) Research in systematic biology has been subject to bursts of activity caused by the adoption of new methods. Many new techniques are available and are of importance in countries where the plant, animal and microbial resources are already known. For example, in Europe orthodox taxonomic studies of the flora are less important than in third world countries, but a fuller understanding is required of how genetic variants of species may survive in a changing environment. The lack of financial support prevents full exploitation of computerised data bases.

(vii) The funding base of our major institutions appears to be insecure. They have been slow in taking advantage of new techniques but their importance lies in the fact that they house the most complete and important collections.

(viii) The developed countries have a major responsibility for research in systematic biology but as the important economic prospects lie in the developing countries, UN programmes should be expanded to share the burden.

In certain areas of research, industry may benefit but it is impossible to convince companies of that fact until an obvious product emerges.

(ix) Teaching in systematics is woefully inadequate and inferior to many European countries. Certainly traditional systematics is unfashionable and most biologists receive very little in their training. This need not be the case if modern techniques were included in the syllabus.

(x) The health of research in systematics appears to be far superior in Europe and the USA to that in the UK. There is some evidence to suggest that the application of modern techniques in Japan and the USA is greatly in advance of this country.

Evidence from the University of Cambridge, Department of Zoology

Thank you for sending me a copy of the written evidence submitted to the sub-committee on Systematic Biology Research.

I have read with interest the various comments, opinions and evidence contained in the document. I also attended the meeting convened at the Royal Society yesterday, by The Linnean Society and the Systematics Association, on the theme of "An appraisal of taxonomy in the 1990s". There seems to be a surprising consensus as to the state of crisis confronting taxonomy today. However, an overall impression is that there is a shortage of down to earth practical proposals, which take account of the realities confronting both the institutes of higher education and the Natural History Museum. I make so bold, therefore, as to put some specific proposals forward.

I am taking it for granted that the rest of biology, pure and applied, looks to taxonomists to provide the following:—

1. An identification service.
2. User-friendly keys to allow non-taxonomists to identify specimens for themselves.
3. The most useful classification system for species.
4. A system of stable nomenclature for species, and higher categories, that is universally accepted.
5. A collation of the biological data for each group of organisms, as a resource for ecology, conservation, and other disciplines and concerns.

I am also taking it for granted that, despite the excellent work being done already, the level of financial support is currently inadequate for the magnitude of the task, and the heightened urgency created by the current rates of habitat destruction and consequential species losses.

Granted that there needs to be a massive increase in the level of funding for taxonomy, I suggest the most cost-effective measures in the immediate future would be the following:—

1. In order to get taxonomy back into the Universities and Polytechnics, without aggravating the current financial strains they are trying to master, there needs to be established a system of both senior and junior research fellowships, based in Institutes of Higher education but funded from a separate source. I suggest that The Linnean Society of London should establish an endowment fund to finance these fellowships, which will be administered by that society. In order to get this going it will need a substantial pump-priming funding from the public purse. I suggest a minimum of fifty million pounds. Thereafter it can be augmented by public appeal, legacies, and so on.

2. Likewise an endowment fund for research fellowships based in museums should be established. As the biggest single task confronting taxonomy is the enormous insect fauna of the world, there is a case for providing an equivalent pump-priming injection of funds to the Royal Entomological Society of London to administer this endowment fund.

3. The problem of space at the Natural History Museum is a crisis that is rapidly approaching. This should be seen as an opportunity, not a problem. I propose that the research function, along with the collections and libraries, be relocated and established as the British Institute of Systematic Biology. The South Kensington Museum will then acquire the extra space that would allow the exhibition and education function to be expanded to a scale worthy of Britain's premier museum of natural history.

4. The location of the BISB should take account of the following considerations:—

- (a) It should be nearer the geographic centre of Britain than London.
- (b) It should have excellent road and rail links.
- (c) It should be in close proximity to at least one Institute of Higher Education.
- (d) It should have affordable housing, to make it easier to recruit able staff currently inhibited from applying for posts at the Natural History Museum because of the costs of housing and/or commuting in and near London.
- (e) Other things being equal, it should give preference to a location where current employment opportunities are poor.

In the light of these criteria the location that seems to fit the bill on all counts is Sheffield.

The proposed establishment of a British Institute of Systematic Biology will have to be funded by the public purse. The expansion of the exhibitions at the Natural History Museum, following the enormous increase in available space, could probably be funded to a large extent by commercial sponsorship.

I hope the sub-committee will find these proposals both helpful and realistic.

Dr R H L Disney

Field Studies Council Research Fellow

Paper by J. Parnell, Botany School, Trinity College Dublin, Ireland

Plant taxonomic research: problems and potential solutions

ABSTRACT

The rate of completion of tropical floras is both very low and very slow. Research funding councils could at relatively little cost correct this by adequately funding existing projects. The position of "European" Universities as centres for taxonomic research and training has declined in relative terms since 1959 despite the increase in the number of taxonomists employed. Nevertheless, at present, there are still many more plant taxonomists and specimens in "Europe" and the U.S.A. than there are in the tropics. Over the past thirty years "European" Universities have retained their very large collections of tropical material but now have a relatively small and ageing population of tropical taxonomists to work on them; over the same period there has been a huge increase in the numbers of taxonomists and plant taxonomic institutions in the tropics. The trends in the UK contrast with those in "Europe" as plant taxonomic staff numbers have declined in both absolute and relative terms there from the early 1960's on. There are now fewer plant taxonomists in the UK than in Denmark. Nowadays tropical countries have the personnel and institutions but not the reference specimens. "Europe" should correct these deficiencies by offering scholarships to taxonomists from the tropics to work in "Europe". Equally scholarships for "European" taxonomists to work in the tropics must also be offered so as to optimise the use of the "European" collections.

INTRODUCTION

There is a growing feeling that we need to know more about the plants and animals that live on Earth than we do now. Certainly we should be ashamed that we do not know, and cannot accurately estimate, the numbers of species of living organism. This represents not merely a wish to catalogue the diversity of life but also involves the realisation that many unstudied species contain substances of potential value to man as drugs, food or as starting products for industrial transformations. Our lack of knowledge is most acute in the tropics where the greatest diversity of species occurs. Unfortunately, as is well known, that great diversity of species is under threat; much of it will be lost in the next 30 years.

It is the role of Taxonomy or Systematics to describe the living world. So at least some of the blame for the failure to catalogue the living world must lie within this field of science. In this paper I examine some of the reasons for the seemingly poor performance of plant taxonomy—particularly tropical plant taxonomy—and try to suggest possible remedies.

One of the most important products of Plant Taxonomy, which is also a good measure of plant diversity, is the floristic inventory. Such inventories enumerate the plant species which grow in particular areas of the world. Unfortunately the rate of completion of such floristic inventories, especially those which deal with tropical areas, is abysmally slow. Estimates have been published (Prance and Campbell 1988) which indicate that *eg* *Flora Neotropica* will take 381 years to complete at the present rate of progress; and that the fungi for the same area will take 948 years to finish! Unfortunately *Flora Neotropica* is far from being exceptional—for example I estimate that it will be 198 years before *Flora Malesiana* is completed and published and between 80 and 154 years before we can put the last part of the *Flora of Thailand* on our bookshelves. There are some bright spots *eg* there have been two complete editions of the magnificent *Flora of West Tropical Africa* published, the *Flore de Madagascar et des Comores* is over 75 per cent completed and both the *Flore des Mascarenes* and the *Flora of Tropical East Africa* should be completed in 40 years time. In general however the rate of progress is too slow. There are a number of reasons for this—I would like to isolate two of them; the first is primarily financial whilst the second is structural.

FINANCE

Firstly it is clear that a number of floras are hampered by a lack of basic funding. This can be manifested in a number of ways—perhaps the most frustrating is where an author has completed a revision, written it up and produced a manuscript but has never seen his manuscript in print because there is no money available to publish it. The information contained in such accounts is effectively unavailable and so of very limited value. One very good example of this is the excellent manuscript account of the large and important plant family Cucurbitaceae (the gourd or loofa family) for the *Flora of Venezuela* which though submitted and accepted in 1975 has still not been published. Other financial problems are less obvious but equally frustrating, *eg* the relatively slow rate of progress and publication of the *Flore du Cambodge, du Laos et du Vietnam* (which is being produced in Paris) can be partly attributed to a lack of long-term and substantial financial commitment to the project by the government bodies responsible.

In fact a relatively small injection of money aimed at publishing completed manuscripts would produce immediate results and would dramatically increase the rates of publication of a number of Floras. Such an effort should, I feel, be a priority for research council funding.

INFRASTRUCTURE

Despite problems of finance most taxonomic botanists would claim that the main underlying cause for the poor progress made so far is that the resources (*i.e.* numbers of taxonomists, specimens, institutions) available to do the job are too small. To my astonishment I can find no evidence that anyone has produced evidence to justify this assertion. In actuality the data, at least for plant taxonomists, are readily available and can be abstracted and collated from the various editions of *Index Herbariorum* (eg Lanjouw & Stafleu 1959, 1964, Holmgren, Keuken & Schofield 1981 and Holmgren, Holmgren & Barnett, 1990).

The data I have extracted relating to the above parameters have enabled me to plot changes and compare the infrastructure of University based plant taxonomy over the past 30 years in Europe (defined in a broad sense to include Scandinavia and Turkey but excluding the Soviet Union West of the Urals and indicated as >Europe on diagrams and as "Europe" in the following text) with that in the tropics and to a lesser extent in the USA and the UK. I have concentrated my analysis on "Europe" because of the current concern there about the status of taxonomy and because of "Europe's" long history of research in the area. I have focussed on the University system firstly because, Universities are responsible for training most plant taxonomists and secondly Universities are themselves considerable resources of plant taxonomic expertise. One difficulty I have had to face is that although it is possible to extract total numbers of employees, herbaria and specimens easily from *Index Herbariorum* it is much more difficult to isolate the numbers of taxonomists, tropical taxonomists, tropical specimens and numbers of Universities undertaking tropical research. For example in *Index Herbariorum* the research interests of some individuals are clearly stated eg "Orchids of S.E. Asia" whereas for others secrecy appears paramount and there is no information at all as to that person's research interests. This has meant that I have had to make a number of, I hope, educated guesses. In the case of specimens I have, I think reasonably, assumed that if there is someone working in an institute on tropical plant taxonomy then there will be some tropical plant specimens there too. I have made a conservative estimate, based on my own herbarium (TCD), that 30 per cent of the total holdings of such an institution will be of tropical provenance. This assumption may underestimate the real number of tropical specimens held as institutions which have abandoned their research in the tropics will not be recorded as possessing any tropical specimens; also there are some very large European University herbaria which have long-term research projects in the tropics and a history of acquisition of tropical specimens and where more than 30 per cent of their specimens are likely to be tropical in origin. However in neither case is the error likely to be very large—probably much less than 10 per cent. Such errors may become relatively more important when the sample is very small *eg* for a single country.

ANALYSIS OF INFRASTRUCTURE

1. Numbers of Universities and Herbaria

There were, in 1990, slightly fewer than 2,000 Universities in the world. Of these approximately 45 per cent (871) had herbaria. Of these latter approximately 30 per cent could be found in the USA, 25 per cent in "Europe" with 17 per cent in the tropics (Fig 1). In "Europe" there were approximately 400 Universities of which approximately 50 per cent had herbaria. As herbaria are the basic research tool of any systematic botanist one might think that in terms of potential research sites for taxonomic training "Europe" is at least in line with the world average. However as can be seen from Fig 2 back in 1959 "Europe" made a far more substantial contribution; at that time approximately one third (35 per cent) of all University herbaria were located in "Europe"—by 1990 this had fallen to approximately 26 per cent. The decline in the relative number of University herbaria in "Europe" is at least partly due to the increase in the number of Universities in the tropics. In fact the number of University herbaria in the tropics has multiplied more than 7-fold since 1959. By any standards this is an admirable achievement. Yet despite this the number of herbaria in the tropics is still fewer than in "Europe" despite the former's much more species-rich flora. "European" countries might do well to emulate tropical countries by ensuring that any new Universities created contain herbaria.

2. Numbers of Plant Taxonomists

If we now turn to the personnel who staff the University Herbaria we can see (Fig. 3) that there has been a substantial increase on a worldwide, "European" and Tropical basis in the total number of plant taxonomists (*c.* 3,000). Holmgren *et al.* (1990) state that there are 7,627 staff in total in all herbaria worldwide. Not all of these latter are in fact plant taxonomists—a surprising number of herbaria are run by scientists from other disciplines *eg* biochemistry or plant physiology. Allowing for this enabled me to estimate that about 45–50 per cent of the plant taxonomists in the world are employed in the University system. These *c.* 3,000 taxonomists are far from evenly distributed globally. Despite the more than five-fold increase in the numbers of plant taxonomists in the tropics between 1959–1990 (now *c.* 520) there are still many more taxonomists in "Europe" (*c.* 1,000) and the USA (*c.* 650) (Fig. 4). Therefore there are far more plant taxonomists working in the temperate zone than the tropics despite the fact that the greatest numbers of species occur in the tropics.

3. Numbers of Tropical Plant Taxonomists

Of course only a limited number of "European" and USA based plant taxonomists centre their research interests in the area of greatest biodiversity *ie* the tropics. In Figs. 5 and 6 I have isolated the percentages and numbers of plant taxonomists whose primary interest is in this region. Clearly, as can be seen by comparing, Figs. 3 and 5 only a small percentage of the University based plant taxonomists in the world (20 per cent worldwide; 15 per cent in "Europe") are working on primarily tropical taxonomic problems. Of these by far the majority (69 per cent) are based in the tropics—there are only 149 (19 per cent) in "Europe" (Fig. 6). This in fact represents a substantial decline in the relative proportion of tropical plant taxonomists in "European" Universities over this period because in 1959 35 per cent of the tropical plant taxonomists in the world were based in "Europe" (Fig. 5). This relative decline has taken place because of the dramatic increase in the numbers of tropical plant taxonomists working in the tropics (more than five fold—see above) and despite the growth in the absolute numbers of tropical plant taxonomists over the past thirty years (Fig. 5). Of course this increase is not evenly spread and in some tropical countries *eg* Burma or Thailand the number of plant taxonomists in Universities is declining or soon will do so. However, in general, tropical countries are doing better in terms of employing tropical plant taxonomists than their "European" counterparts. This is due to the importance that tropical countries place on plant taxonomy: they have enshrined it in their new Universities and have made sure that there are an adequate number of plant taxonomic staff employed.

Incidentally another point that is easily seen from Fig. 6 is that despite the increase in numbers of University based tropical plant taxonomists over the past thirty years—the total numbers still remains low (<800). In other words it would seem that there are indeed relatively few tropical plant taxonomists.

4. Numbers of Plant Specimens

Plant taxonomists need large reference collections of preserved plant material to undertake their research. As might be expected the total numbers of herbarium specimens of any provenance held in Universities both worldwide and in "Europe" has grown over the past 30 years as has the number of specifically tropical specimens (Fig. 8 and 9). In fact the total numbers held in Universities are now astonishing. On a worldwide basis just under 50 per cent (126,000,000) of the total number of specimens held in all herbaria of all types worldwide are in Universities (53,000,000 in "European" Universities alone). Of course not all of these specimens are tropical but I estimate that "European" Universities probably hold about 10 million tropical specimens—40 per cent more than the total number of specimens held in one of the world's largest herbaria, the Royal Botanic Gardens Kew. In other words approximately 19 per cent of the specimens held in the herbaria of "European" Universities are tropical (versus approximately 18 per cent on a world-wide basis)—for once "Europe" does not appear to be proportionately out-of-step with the rest-of-the-world. In fact, this is one of the real troubles. As Fig. 10 shows approximately 45 per cent of the tropical specimens held in University herbaria are held in "Europe" with only 26 per cent in the tropics. A comparison of this figure with Fig. 5 shows that there is a clear miss-match between the geographical distribution of tropical plant taxonomists and tropical specimens. "Europe" has a large number of tropical specimens but relatively few people at present working on them. By contrast tropical countries have more personnel but very little material for them to work on.

The above problem is compounded by the fact that wherever they are based, tropical taxonomists have a very strong obligation to make repeated visits to "European" herbaria. Not only do these herbaria contain very substantial collections of tropical material; they also contain the majority of type specimens of tropical species. From the perspective of the tropical plant taxonomist working in the tropics it is very frustrating not to be able to access the essential reference (type) specimens because he cannot afford the necessary travel.

5. Age structure of Plant Taxonomists

One of the areas of greatest concern in "Europe" lies in the age structure of the plant taxonomists employed. The latest edition of *Index Herbariorum* (Holmgren *et al* 1990) shows that 25–30 per cent of all taxonomists at present employed were born on or after 1950. By contrast in the European Universities only 20 per cent of those tropical taxonomists employed *ie* 28 people fall into the same class. In other words the age distribution of tropical taxonomists in European Universities is skewed. There is bound to be a severe decline in the numbers of tropical taxonomists employed in "European" Universities in the near future as people retire.

6. The situation in the UK

Historically UK Universities have considerable resources of plant taxonomic expertise. Indeed they still retain their large collections of material (allowing for errors in the estimation of the size of the collections in Manchester gives a number somewhere between 3 and 5 million specimens). However, the numbers of plant taxonomic staff employed in UK Universities has fallen over the period in consideration (by 20 per cent since 1964). I estimate that by 1990 there were about 31 Botanical taxonomists employed in UK Universities. Thomas (1991) notes a similar decline in the number of

plant taxonomists: indeed he estimates that by 1991 there were only 22 plant taxonomists left. This may be overly pessimistic: nevertheless even my more optimistic estimates enable some startling comparisons to be made *eg* there are now fewer University based plant taxonomists in the UK than there are in Denmark. The decline in taxonomic staff has led to acute staffing shortages. In fact by 1990 just under half (47 per cent) of the total number of University Herbaria in the UK (36) appear to have no taxonomic staff at all.

It is very difficult to accurately estimate the numbers of tropical plant taxonomists in UK Universities: however the number is round-about 8. Not only is this a very low number but it is also less than the corresponding figure for Denmark and additionally is likely to decline as at least three-quarters and possibly all of the staff concerned were born before 1950 (2 staff have refused to state their age).

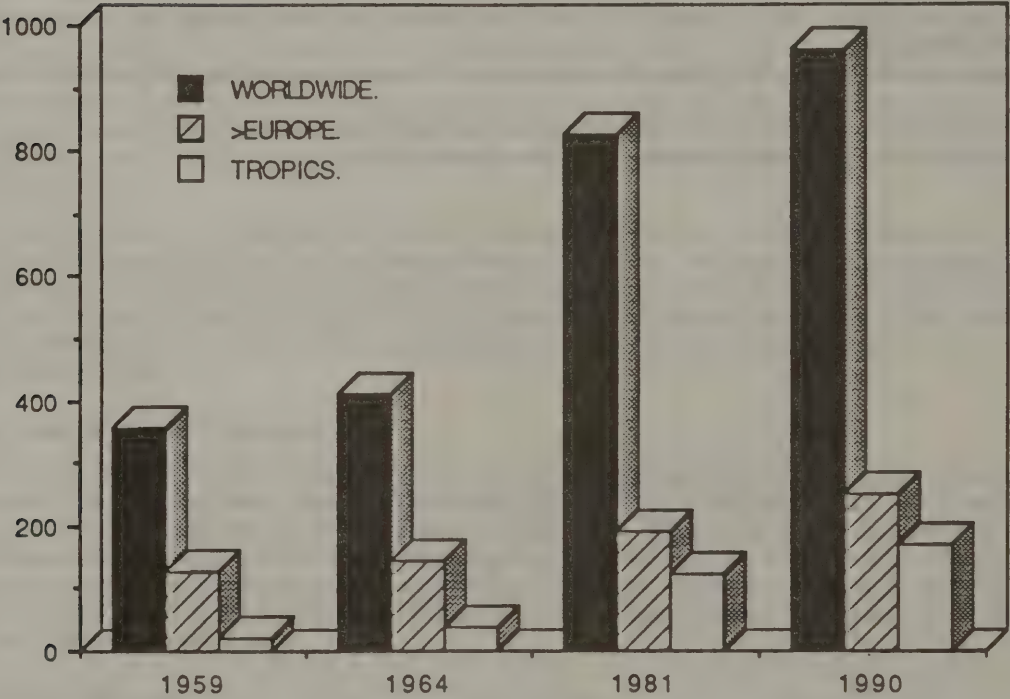
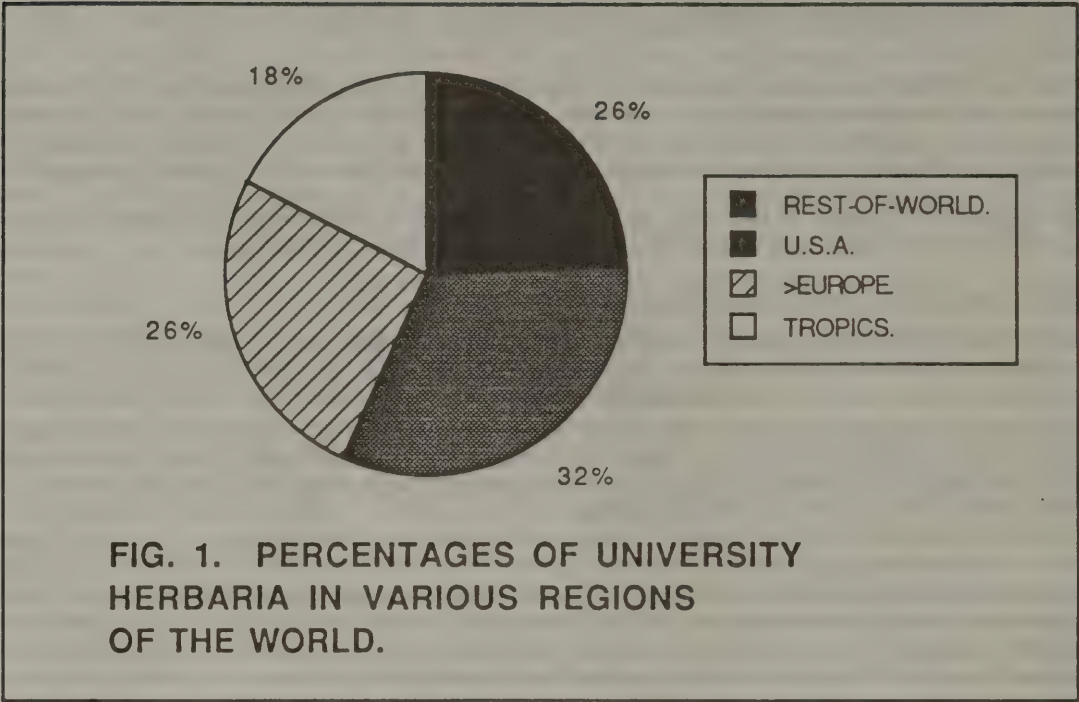
In summary the pattern of declining taxonomic staff numbers in the UK is the reverse of the trend of increasing numbers of taxonomic staff evident in "Europe" and the tropics.

7. What can be done about the problems of poor infrastructure.

It is difficult to propose achievable solutions to these infrastructural problems which will quickly result in the desired increase in the rate of taxonomic activity. There is, inevitably, a long lag between the recognition of the need for more taxonomists followed by their subsequent training, which may take more than six years, and their subsequent employment. It will continue to be very difficult to encourage young people to train as taxonomists unless it is clear to them that there will be jobs for them to go to on completion of their studies. In the meantime we must make the best use of the resources available. Considerable effort must be put into increasing taxonomic mobility so that the plant taxonomists in the tropics who lack the herbarium material necessary for their work are encouraged to come to "Europe" and the USA where that material is located. Equally "European" and USA based plant taxonomists interested in tropical problems must be encouraged to visit the tropics to pursue their research interests and money must be available to publish their results (see section on Finance above). Effort must be made to re-direct the research interests of that vast body of plant taxonomists in the Universities of "Europe" and the USA who are largely concerned with non-tropical problems. They must be encouraged to expand or even to transfer their research interests to those areas of greatest biodiversity—the tropics—before that biodiversity disappears.

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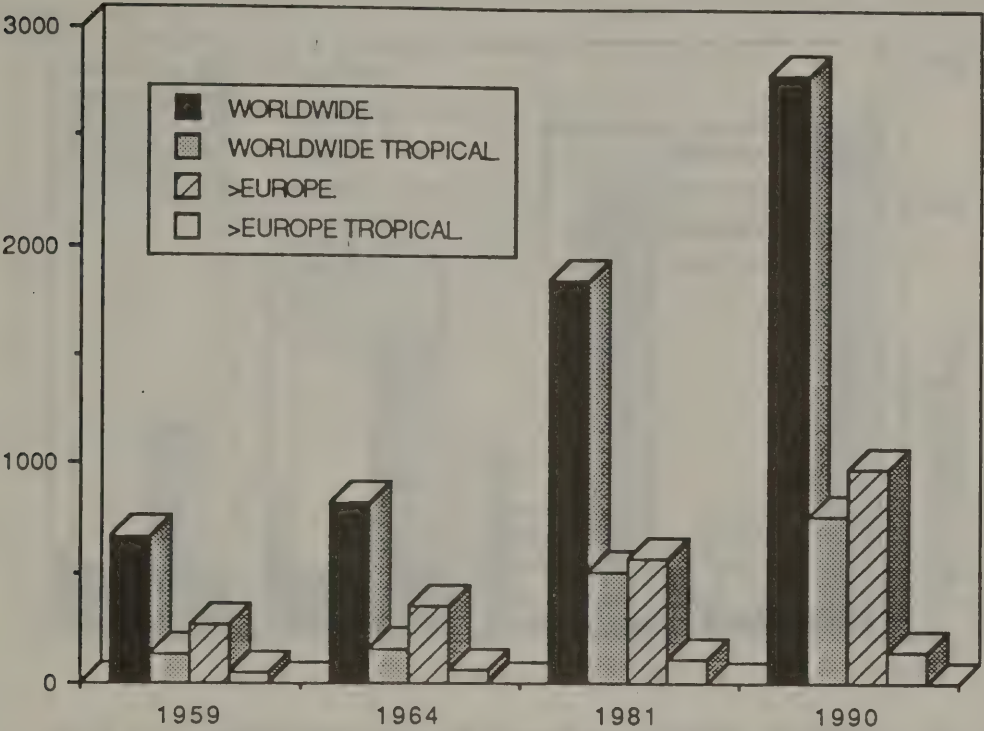


FIG. 3. TOTAL NUMBERS OF UNIVERSITY PLANT TAXONOMISTS.

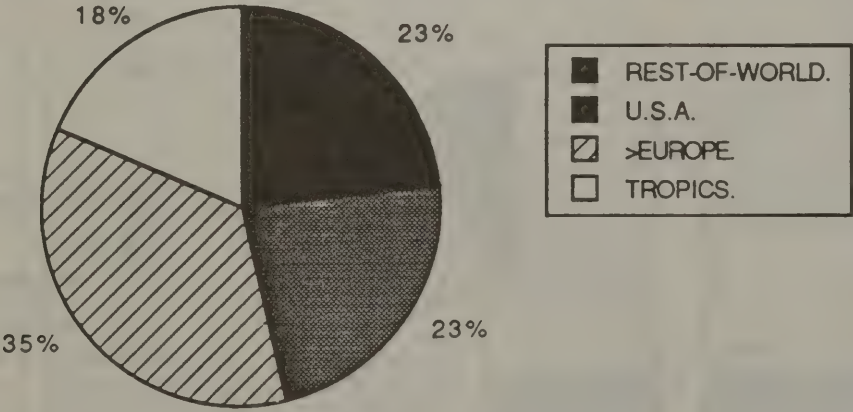


FIG. 4. PERCENTAGES OF UNIVERSITY PLANT TAXONOMISTS IN VARIOUS REGIONS OF THE WORLD.

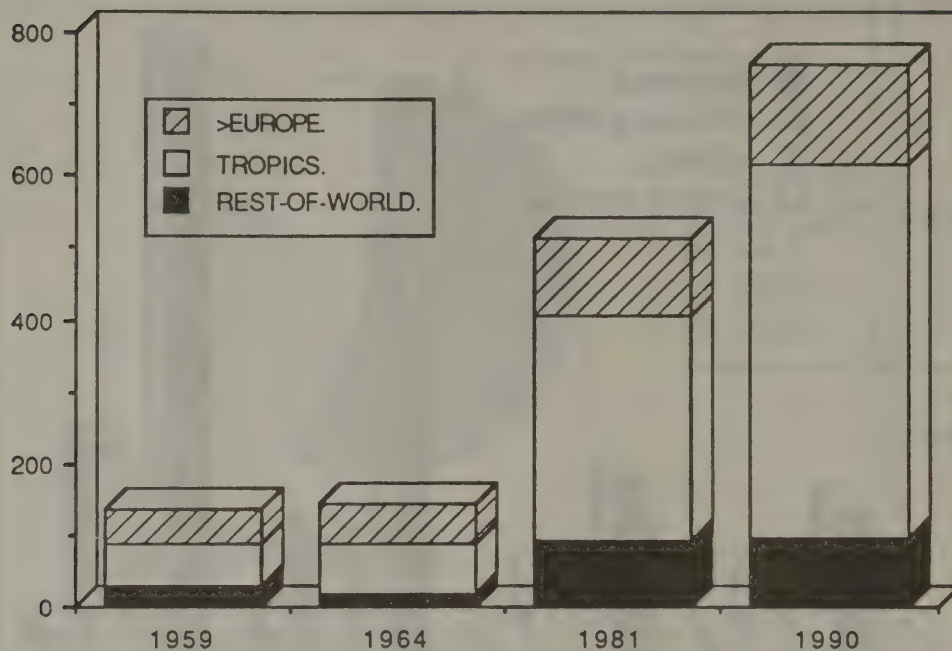


FIG. 5. TOTAL NUMBERS OF TROPICAL PLANT TAXONOMISTS IN UNIVERSITIES AT VARIOUS DATES.

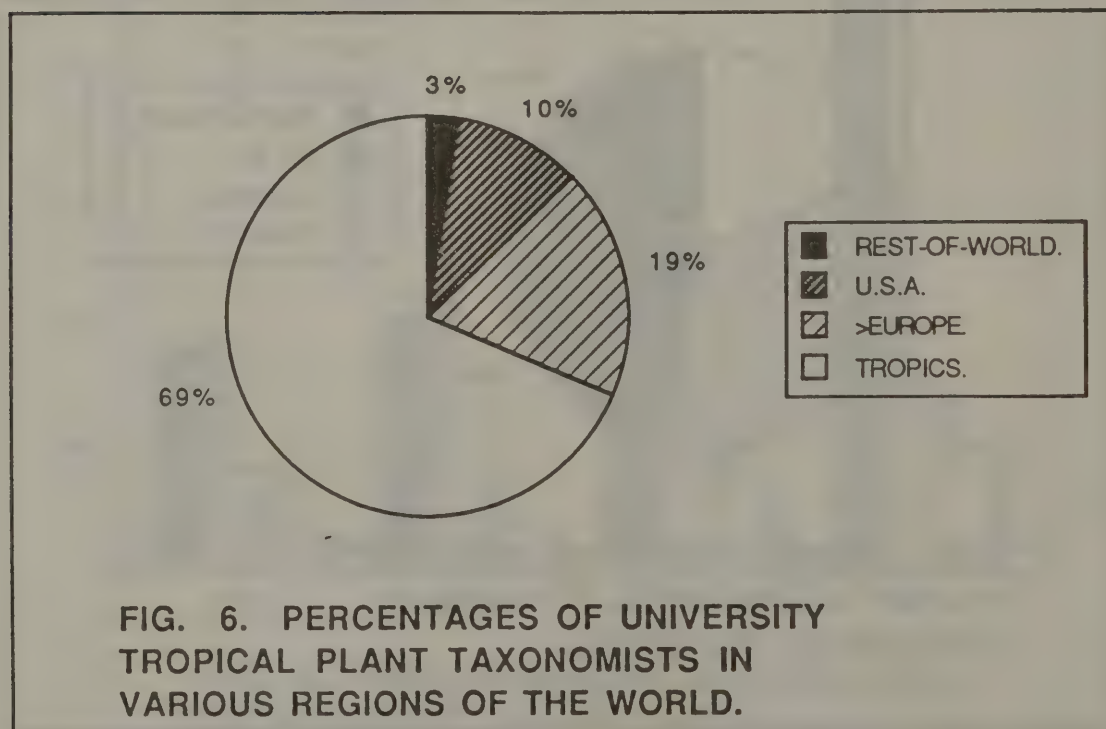


FIG. 6. PERCENTAGES OF UNIVERSITY TROPICAL PLANT TAXONOMISTS IN VARIOUS REGIONS OF THE WORLD.

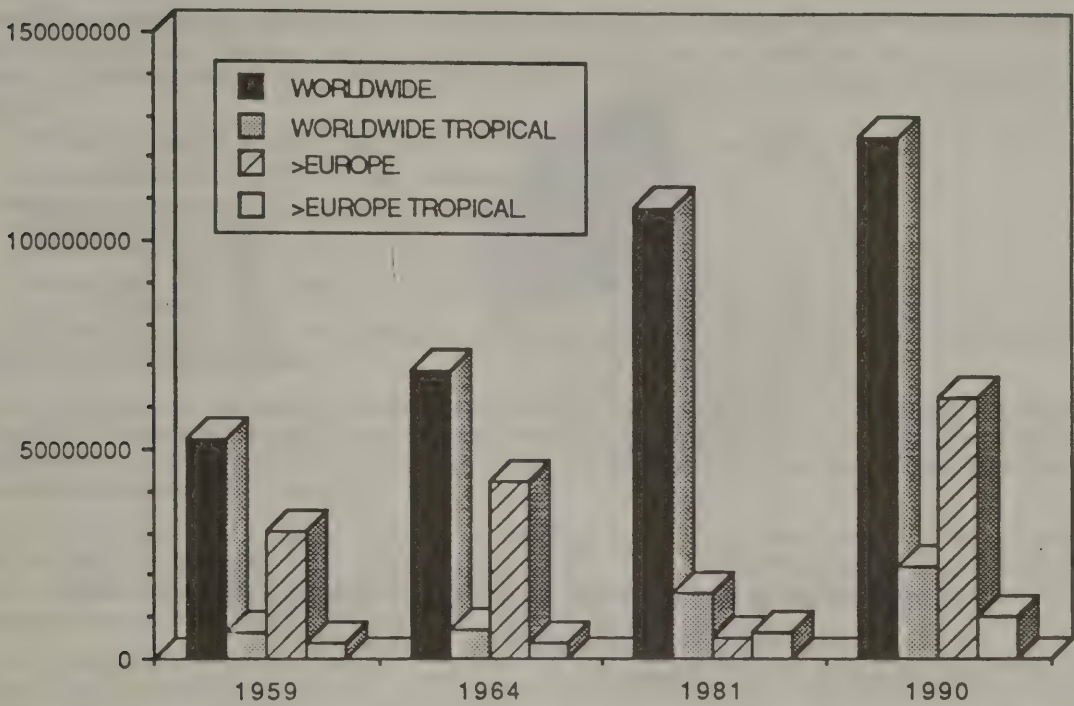


FIG. 7. TOTAL NUMBERS OF SPECIMENS IN UNIVERSITY HERBARIA AT VARIOUS DATES.

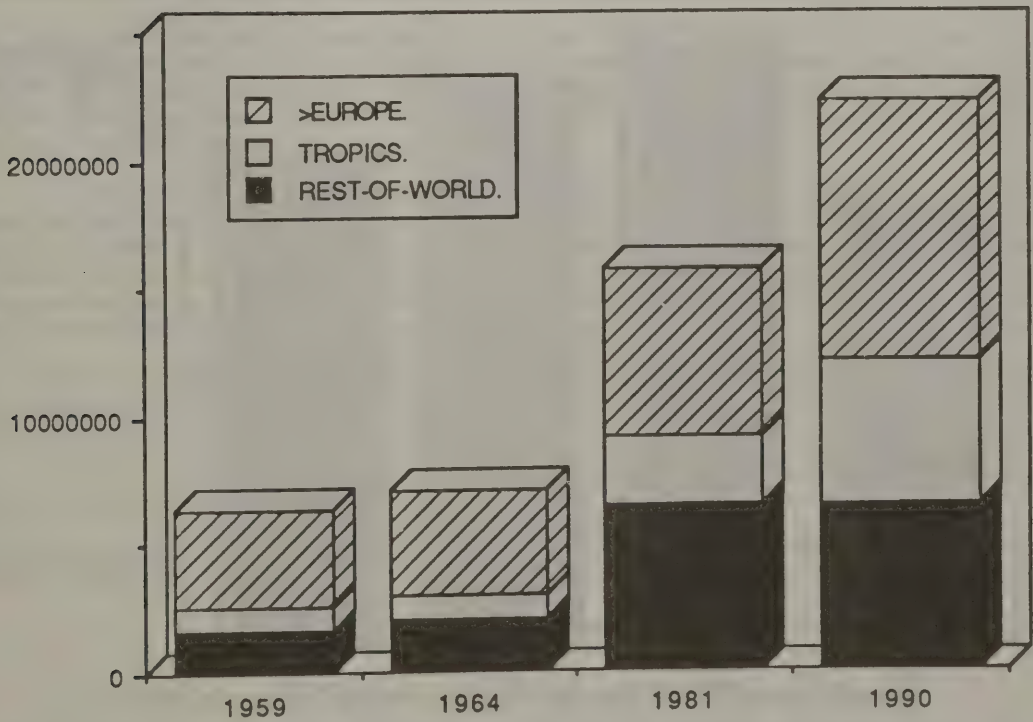


FIG. 8. TOTAL NUMBERS OF TROPICAL SPECIMENS IN UNIVERSITY HERBARIA.

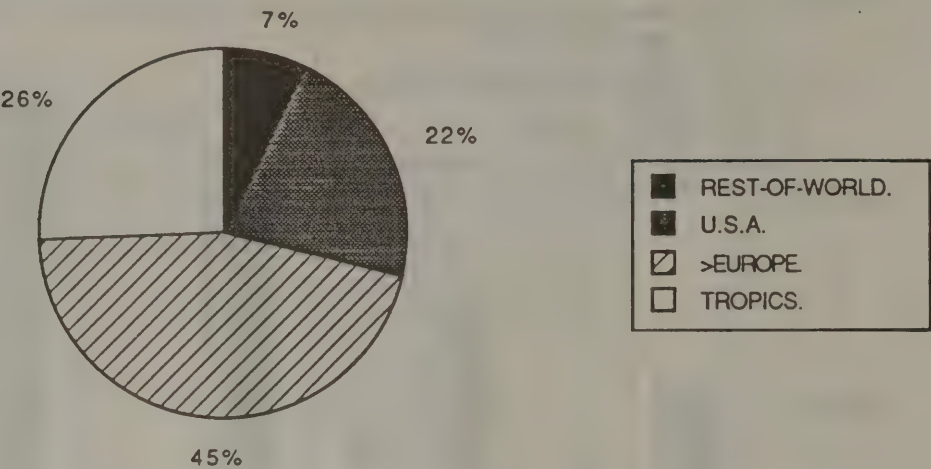


FIG. 9. PERCENTAGES OF TROPICAL SPECIMENS HELD IN UNIVERSITY HERBARIA IN VARIOUS REGIONS OF THE WORLD.

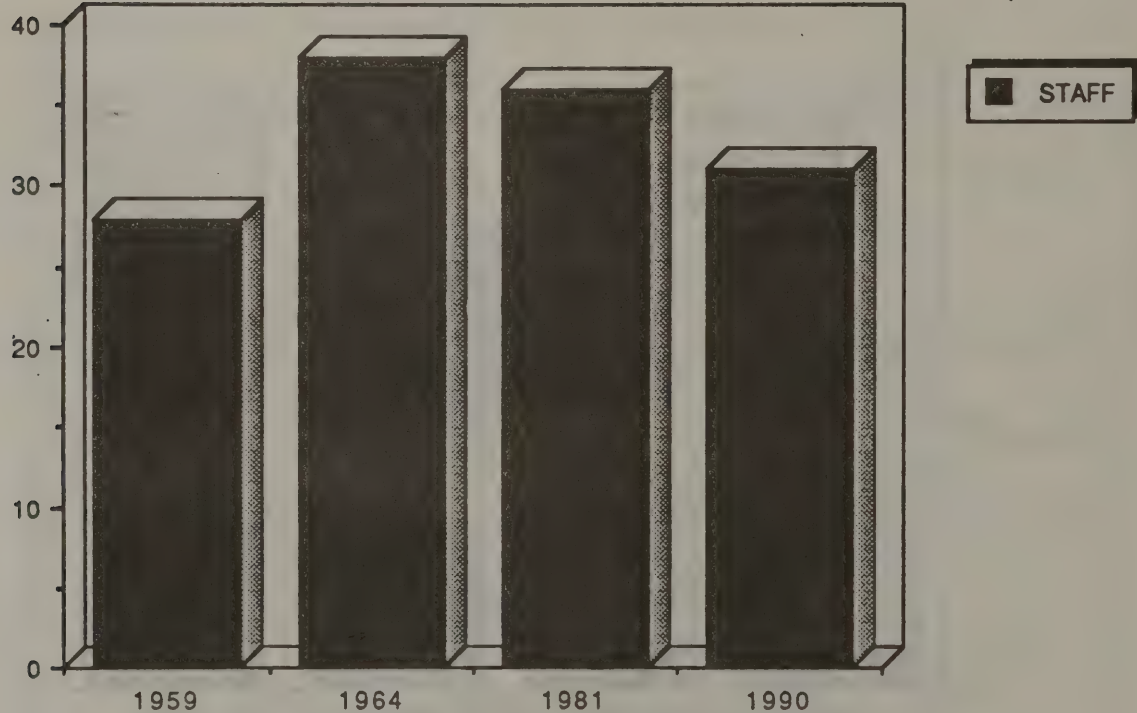


FIG. 10. NUMBERS OF PLANT TAXONOMIC STAFF OVER TIME IN U.K. UNIVERSITIES.

Evidence from the University of Newcastle upon Tyne

(i) Systematic biology research is essential to underpin teaching and pure “studies” on biology, ecology, genetics, population dynamics etc. To approach this entirely from an utilitarian standpoint would be wrong as there are numerous examples of where “pure” research has proved to be of practical value such as:

- climate change (eg oceanic stratigraphy, palynology, dendrochronology)
- new crops/medicines, ethnobotany, combating desertification etc
- extinction/habitat loss/endemism/gene banks etc
- forensic science, eg diatomology, DNA fingerprinting
- evolutionary processes, plant and animal breeding etc

(ii) Yes as, for example, in the protection of rare species and to ensure that trials are conducted using the correct organisms for tests.

(iii) Some believe that funding for this area is probably the most neglected of all biological disciplines because it is considered unfashionable. Matters are becoming worse because there are diminishing funds available from Research Councils. The appropriate volume should at least ensure that some work is funded on each taxonomic category.

(iv) If priorities have to be determined it is essential that work is carried out on important groups such as rare, economically and environmentally sensitive flora and fauna; pests, pathogens, biological control agents (especially parasitic Hymenoptera) and environmental indicators. It is also important to make best use of the expertise and experience currently based in the UK.

(v) Systematic research is crucially dependent on reference collections, and levels of storage and curation cannot be too high. We have a responsibility to the world community as the country holding the single largest set of collections of Types in almost every discipline. Consequently there is a need for a properly financed national reference collection.

(vi) New methods such as genetic “fingerprinting” and chemical taxonomy are a useful supplement to classical methods, but do not replace them. Information technology is not sufficiently exploited even where national databases are in existence as they cannot function to full capacity because of under-funding. It is impossible to assess the biological impact of environmental change without a database on the systematics and distribution of our existing flora and fauna.

(vii) The institutional infrastructures already exist and should be supported but their funding base and future are uncertain. There should be a firm commitment to fund continued research in systematic biology at an adequate level. Much of this research is essentially long-term; without some promise of continuity, it will not attract top quality researchers. The NHM should be the responsibility of the DES as its rôle is primarily educational.

(viii) As long as bureaucracy can be kept to a minimum the UN and EEC should be encouraged to support programmes with an international interest, eg gene banks, threatened species projects, and typological collections. The Government through its agencies should provide sufficient money to support the Research Councils adequately, at least at their present level, so that there is no further deterioration in their funding and to make up the loss of funding in real terms that has occurred over the last few years. Industry cannot be expected to support basic biological research.

(ix) Teaching in systematic biology is unfashionable, and increasingly neglected. Students must be made aware (at all levels of biology teaching) of the inherent diversity of biological organisms, and the need to classify this diversity.

There is a severe shortage of trained systematicists which, if allowed to continue, will reinforce current trends in university teaching.

(x) Systematics has a much higher profile in the USA. There are more funds available for research and there seems to be more government support for institutions similar to the NHM.

Evidence from the University of Newcastle upon Tyne, Hancock Museum

I have pleasure in returning the completed form relating to Systematic Biology in the Hancock Museum.

Incidentally, I note that in your appended list of institutions we are classified as a local authority museum. This is incorrect, we are administered by the University of Newcastle under an agreement signed in 1974. Previous to this the museum was a private institution, run by the Natural History Society of Northumbria, (founded 1829), who still own the building and its contents.

The collections that the Hancock Museum holds are of considerable importance for taxonomists and systematists, with special strengths in coal-measure vertebrate and plant fossils, (Atthey Collection, Hutton Collection etc) and in marine biology (Joshua Alder, George Hodge, George Stewarson Brady etc) The last-mentioned collection is of great importance, with more than 500 type and figure specimens of microcrustacea, and is used by researchers around the world. In addition to these important taxonomic collections, we also house material of great significance in the history of science, ranging from the drawings and watercolours of Thomas Bewick to the first wombat and platypus to arrive in Britain from Australia. All these collections are used regularly by researchers, scholars and students.

Despite the significance of these collections, the University of Newcastle does not look upon us favourably or regard the curatorial work we carry out on the collections as significant—in their words “The Hancock Museum has little direct relevance to the academic activity of the University” (Report of Planning and Resources Committee to Senate, 22 May 1991). We are currently threatened with closure unless we can demonstrate an ability to become less reliant on core funding, making more money ourselves through entrance charges and trading activities. You may have seen articles in the press recently relating to our possible closure. These extra pressures on us mean even less time is available for curatorial duties; research of any kind is out of the question.

We find it disturbing that this situation is facing us. It is far removed from the situation of some 30 years ago, when Newcastle University’s Zoology Department established itself as a centre for taxonomic research, with Professor Westoll and Dr Alec Panchen leading the field in research on coal measure vertebrates, using our collections. We feel that the museum and its collections still have a vital role to play, but that it remains underutilised due to the current status of taxonomy in Britain, and the fact that systematics is regarded as unfashionable at present. On a recent visit to America I found the attitude to systematics totally different, fuelled to some degree by the renewed interest in biodiversity, and the rate of loss of species.

Could I explain a little about the figures in our return? They are influenced by the numbers of staff we have, the amount of time we can devote to curatorial duties and a recent change in exhibition policy.

We have three curatorial staff, (a Curator, myself and a geologist), two technicians and a designer. The amount of time we can give to curatorial duties, including documentation and computing varies from one individual to another, and to some extent on other current activities. I have estimated that across the board the time devoted to “hands-on” systematic work (primarily curation, documentation, conservation) is some 30 per cent of total time, and have apportioned salary costs accordingly. The number of staff involved in such work has remained constant over the last ten years, ie there have been no significant changes here.

The reason for the increase in total expenditure in Q1 is related to a change in exhibition policy, not an increase in taxonomic work per se. Since 1988, in order to improve our visitor figures and increase revenue we have mounted large-scale temporary exhibitions. These have some taxonomic element in them (they usually reflect the diversity of life if nothing else), and we now spend quite large sums of money on them, as you will see in Q2. The figure is considerable as it includes our designer’s salary, which we now have to pay from the revenue we generate. Exhibitions are to some extent an “information service”, but in the broadest possible sense. If you feel that these figures should not be included in our return, please amend them accordingly. You will note however that the proportion of money (and time) that these exhibitions demand results in a decline in effort and proportional expenditure on essential taxonomic work. (Q6b).

With the resources we have, no true taxonomic research is possible (Q3). The best we can achieve is to produce catalogues and databases which make the collections more accessible to researchers.

In Q5 I have included only permanent staff. In 1980 and (to a lesser extent) 1985, our curatorial work was aided tremendously by young people employed under Manpower Services Commission schemes. The movement, re-storage, cataloguing and computerised documentation of a large part of the research collections was carried out at this time. The University, as recently as 1980 had a different attitude to the importance of taxonomic collections, when it made a grant of £9,000 through the University Development Trust to enable us to purchase new cabinets and up-grade storage. I suspect an application made today for such a grant would be fruitless. If you would like me to provide figures relating to M.S.C. funded work I can, but as it was carried out by temporary staff I felt it was more logical to exclude them from any calculations.

Although a number of staff in the museum have a teaching commitment (Q8-Q11), this is not the teaching of taxonomy or systematics. Reference is made to the diversity of species during biological conservation courses, and some practicals held in the museum look at plant fossils. However, we are currently planning a new course in museology for zoology students, where the taxonomic element will be significant; this will entail some 20 contact hours.

I hope that the return and this letter are useful. Please let me know if there is other information that you require and I will do my best to provide it.

P S Davis

Deputy Curator

Evidence from The University Museum, Oxford

Professor Sir Richard Southwood has passed me your letter to him of 4 July, regarding the role of the University Museum in the teaching and research of systematic biology.

The Museum exists primarily for the preservation and curation of the University's zoological and geological collections. Additionally, the staff oversee and are actively involved in the use of these collections for undergraduate and graduate teaching and research. As you say in your letter, the links with the Department of Zoology (and also Earth Sciences) are strong and active, both in teaching and research. In the following, brief account I will attempt to outline the nature of these links and the way in which they arose.

The Museum consists of four major collections: the Hope Entomological Collections, the Zoological Collections, the Geological and the Mineralogical Collections. There are four Curators, one for each collection. The Curators are University Lecturers appointed from the teaching staffs of the Departments of Zoology and Earth Sciences. They constitute the main link between the Museum and the Departments. The Curators take it in turns to act as Principal Curator, a post which is held for three year stretches.

In addition to the Curators, each collection has an Assistant Curator (there are two in the case of the Geological Collections, one having arrived from Hull University as part of the UFC review of Earth Sciences), as well as technical staff. There are also central technicians who are not specifically attached to one of the Collections, a Librarian who runs the Museum's library and archives (both of which contain material of direct relevance to the collections), an Administrator, and various central support staff. Except for the salaries of the Curators, all staff and non-staff recurrent funding comes to the Museum direct from General Board, not via the Departments.

The activities of the Museum are overseen by the University Committee for the Scientific Collections in the University Museum. The four Curators are members of the Committee, as is the Linacre Professor of Zoology, the Hope Professor of Entomology (both from the Department of Zoology), the Professor of Geology, and the Professor of the Physics and Chemistry of Minerals (both from Earth Sciences).

There are, therefore, links at several levels between the Departments and the Museum: the Curators are members of the Departmental teaching staff; the Curators and Professors sit on the Museum's governing body; the Professors, Curators and Assistant Curators supervise graduate research on the collections, and use the collections in undergraduate teaching of systematics. Another important link is the use of the collections by other members of the Departments in their teaching and research projects on systematics, palaeontology, evolutionary biology etc.

As for the reason why the present arrangement arose: this is largely a matter of historical accident. The Museum was completed in 1859, despite much protest from many members of the University, to assemble "all the materials explanatory of the structure of the earth, and of the organic beings placed upon it". Originally the building housed the Departments of Astronomy, Geometry, Experimental Physics, Mineralogy, Chemistry, Geology, Zoology, Entomology, Anatomy, Physiology and Medicine. As their needs grew all of these left, the last to go being Entomology which moved to be part of the newly housed Zoology Department in 1978. The result of the gradual exodus of departments was the formation of the Science Area which now surrounds the Museum. The Museum then took on its present function and structure.

I hope this is of some use to Lord Dainton's Sub-Committee. Please let me know if there are more details that are required. Let me say in conclusion that the present relationship between the Museum and the Departments of Zoology and Earth Sciences is a successful and stimulating one. I would be delighted if it provides a formula capable of wider application.

Dr S J Simpson

Principal Curator

Evidence from the University of Sheffield

(i) Systematic research serves to:

- (a) improve the accuracy, speed, practicability and potential usership of identification systems such as keys both written and interactive, and expert systems;
- (b) produce accurate phylogenies of organisms which are essential pre-requisites for understanding many basic biological topics such as co-evolution and biogeography, as well as underpinning a far wider range of subjects from molecular evolution to behavioural and ecological adaptations.

(ii) In many fields, for example biological control and genetic engineering, requirements for up to date and well-founded nomenclature are likely to become increasingly crucial both for practical scientific and economic purposes and for their attendant legal regulation and application.

(iii) in our opinion systematic biology research is under- and inadequately funded in the UK in terms of its real needs and in relation to funding in similar western countries such as the USA and Canada. Assessment of an appropriate level might be approached by considering publication output and government funding in an analogous set of countries, though in the case of the former it would be advisable to discount work by amateur systematists who have traditionally been a predominantly British institution. Another, though related, index would be to consider the proportions of university biological sciences staff who are largely devoted to systematics research, over a range of countries. In the UK we believe that the proportion will again be markedly less than in comparable western countries.

The need for systematics research is growing not declining as the trend in UK funding would indicate. Growth requirements stem from:

- (a) the current research interest and widespread concern in global biodiversity and its rate of loss due to habitat change, and
- (b) the development of new techniques in both data acquisition (chemical, molecular genetic, ultrastructural) and handling (computerised analytical methods) which have enabled more thorough and accurate treatment of systematic problems often with the result that past views need to be re-appraised and even rejected.

A correlated factor with the level of systematics research in the UK is the extent of systematics teaching at universities and colleges. With so few university staff actively involved in this research field, teaching of systematics has declined and in some institutions has been virtually lost altogether. Quality teaching of systematics at both undergraduate and postgraduate levels can only be done by persons with a thorough knowledge of the subject and for the most part these should be experienced in systematics research themselves.

- (iv) Only partly. The UK fauna and flora is itself one of the best known in the world but still there are significant gaps in our knowledge. However, treatment of the home fauna and flora cannot be done in isolation.

Economic and ecological importance have been and will continue to be major factors in determining priorities for research, but there are many groups of organisms which can justifiably be claimed to fall into these categories. Current coverage of these in the UK is inadequate. It must not be forgotten, however, that systematics is intimately involved with our understanding of many biological processes and thus there are requirements based in pure as well as applied biological science. Thus the quality of the scientific argument in favour of carrying out a particular piece of systematics research should also be considered as well as direct economic benefit.

Existing expertise is likely to be correlated with those groups that have justified continuing systematics research and should therefore be built upon. During their careers, systematists build up vast stores of knowledge relating to their groups. Thus although the principles and techniques of systematics are largely transferable from one group to another, the systematist's expertise can only shift more slowly.

The major collections of many groups of organisms held in UK institutions such as the Natural History Museum, make a solid foundation for systematics research that is lacking in, for example, third world countries. For most groups it would be foolish to embark on a major systematics research project in a country where there were only scant related collections resources. The quality of relevant resources available in the UK is high for most groups due to historical factors.

- (v) Reference collections are fundamental and essential for systematic research. Because scientifically good systematics research cannot be done in an insular fashion, it is equally essential that we maintain and enhance holdings of foreign material.

Current provisions for storage of Type material is adequate, but there are other essential services which are not. (a) Type material itself is not sufficient for the conduct of good systematics research; it is necessary to examine specimens covering an organism's geographic range and seasonal and ecological spreads to detect any correlated phenotypic variation. It is essential that such collections are also housed safely in major national institutions as when left in universities or private hands, such potentially valuable material has a tendency to become lost or destroyed. Systematics is a developing science and as such there is often a need to re-examine materials in the light of new findings which may in turn lead to improved assessments about species concepts. Therefore there is a need to allow for the selective expansion of non-type collections.

National collections need not only to safely curate their collections but to allow access either through visits or loans to other scientists. It is also desirable that there be trained staff capable of offering identification services. Such staff from curators to identifications scientists need to be trained, some at least at university so that they can appreciate the full scope of systematics and its relationships to the rest of biology.

Finally, the UK has achieved one of the world's finest collections of material from around the globe. Safe housing of such material is essential. It is also better that it is centralised to facilitate access. New and important material is being collected in many parts of the world but provision for sorting, storing

and making this available is inadequate. Thus much effort is wasted. Having an internationally important set of collections we should build from strength and endeavour to keep them as centres of excellence not only from the point of view of the collections but also the research conducted on them.

Evidence from the WRc

Thank you for your letter of 2 May on systematic biology research evidence. We do not conduct any research into systematic biology at WRc, although we use the fruits of such research routinely in our biological field studies. The provision of readily interpretable identification keys for aquatic organisms in both the freshwater and marine environments is essential for our work.

We are not in a position to comment on the status of research in this field other than to stress that this work is the fundamental basis of all ecological studies and it is therefore vital that it is properly funded. It should also be said that adequately maintained reference collections are essential to effective systematic biology research and their upkeep should be given a high priority.

I hope these rather brief views are helpful.

John Davies

Evidence from Wolverhampton Polytechnic

I write as a Principal Lecturer in the Environmental Science section of the School of Applied Sciences at Wolverhampton Polytechnic. I have also discussed your letter with Professor John Packham of our section.

My higher degree studies were in systematic botany but now I am a practising ecologist and therefore my remarks on systematic biology must remain rather general. My experience is emphatically that the systematic aspects of ecology—the study of diversity in particular—are vital parts of the training of ecologists and environmental sciences.

In a wider context, the subject was discussed in detail in the 1979 report “Taxonomy in Britain” produced by the Advisory Board for the Research Council. The Board concluded that taxonomy—which is the study of biological classification and hence systematics—is an essential basis of all science. The most significant way in which this operates is by the provision of accurate, complete, and intelligible treatments of each of the many groups of living organisms. The extent to which this provision is made is the essential test of the efficiency and effectiveness of systematic biology research. It may well be that Information Technology will play an increasing role in providing this essential function, but it must never be forgotten that the treatments must be readily available to a wide range of non-specialists to be useful. In particular I feel that it is important that the organisms themselves rather than the provision of technical equipment, should be at the centre of research.

As in any subject area research is the life blood, bringing new minds and new thoughts into the subject and providing its high level training as well as advancing knowledge. Both Professor Packham and myself feel that much of this should be firmly based in national institutions such as the Natural History Museum and the Royal Botanical Gardens, Kew. There is an implication in the terms of reference of the select committee that this country has a particular obligation to maintain and make available the many reference collections which we have had the good (if expensive) fortune to have acquired. I am certain that this is the case, and it will be disgraceful if these collections become under funded.

I feel that systematic biology is essentially of general utility and therefore unlikely to attract much specific or applied funding. On the other hand the conspicuous success that popular treatments of plant and bird diversity have enjoyed in recent years does suggest that there are profits to be made from good systematics.

Finally, I am not in a position to know accurately how much of a decline there is currently in systematic biology research and therefore my remarks may be too complacent. It will be necessary for the Select Committee to place the current effort in its historical context: to what extent is the current effort greater or less than that recorded in the 1979 report, and what is the state of morale in the leading institutions?

Dr I C Trueman

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